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SCIENCE GLEANINGS

IN MANY FIELDS.

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Studies in Natural History.

WITH 18 ILLUSTRATIONS.

London:

T. NELSON AND SONS, PATERNOSTER ROW.

EDINBURGH; AND NEW YORK.

1884.

shore and ocean depths, cave-deposits and stratified rocks, have alike been laid under contribution, so that new facts have accumulated with unexampled rapidity.

The main purpose in the essays which go to form the present volume has been to present the reader, as far as possible, with the latest facts bearing on the various subjects dealt with, and to exhibit these in the light of modern views.

While many of the essays deal with the purely zoological aspects of animal life, a considerable number treat of animals in their relation to man—that is, in their economic aspect—while the remainder have to do with extinct animals. Together they form the Natural History group of a series of science articles contributed during the past four years to the *Scotsman* newspaper; and I have to thank the Editor for his courtesy in granting permission for their republication. The opportunity, it may be added, has been taken to make a few additions and corrections, rendered necessary in some cases by the interval that has elapsed since the first appearance of the essays.

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I.

ANTLERS.

ANTLERS, if not the most efficient, are certainly the most picturesque of all the weapons in the animal armoury. It is their picturesqueness, indeed, which interferes with their efficiency, and suggests the possibility of the antlers of certain species being not so much weapons wherewith to repel rivals as ornaments by which to attract partners. If the ornament has in this case been developed at the expense of the weapon, it is not more than has happened with many male birds which, as Darwin points out, have acquired ornamental plumes at the cost of retarded flight. The wide-spreading, many-branched horns of the wapiti, the elk, or the red deer must seriously impede the progress of those animals when pursued through woods, while in the open plain their chances of outrunning an enemy are lessened by the antlered weights they carry. Even when used in battle with rival males, antlers have been known to play their owners a trick

which has cost the lives of both combatants—numerous instances being on record of the horns of contending stags getting interlocked. Mr. Scrope tells of two harts in the Duke of Gordon's forests, which, after a furious and deadly thrust, entangled their horns so firmly together that they were inextricable —a situation in which they were discovered by the forester, who killed the survivor whilst he was yet struggling to release himself from his dead antagonist. The elk and the reindeer have been found in a similar plight; and we have seen a pair of wapiti heads from Canada thus joined together in death—the skeletons having been found bleached on the spot where they had fallen. The occasional awkwardness of those head appendages is still further illustrated by the skull and antlers of a red deer exhibited in one of the museums at Vienna, which are seen firmly fixed between the forked limbs of a tree. The deer had got entangled, like Absalom, by its head ornaments, and being unable to extricate them had thus perished miserably. So long had the skull and horns remained in this position before they were found, that when discovered the wood of the tree had by its natural growth to a considerable extent enveloped them.

A curious instance of the modification of a horn in the direction of greater simplicity is found in the Virginian deer, a growing proportion of the individuals of this species found in the Adirondacks having

now merely a spike horn—a branchless, stiletto-like weapon—instead of the branching antlers with which the bucks of this species are still for the most part adorned. The fact that the possessors of the new weapon—a variety that has lately appeared—"are slowly crowding the antlered deer from the region they inhabit" would seem to show that the spike-horn gives them an advantage in the struggle for existence.

That antlers serve an important purpose, whatever it may be, in the economy of the deer tribe, may be fairly regarded as attested by the enormous expenditure of vital power which the periodic renewal of those cranial appendages entails. With oxen, sheep, and antelopes the horns once formed are fixtures; with deer they are shed annually, and have thus every year to be renewed.

The rapidity of their growth is truly extraordinary. Towards the end of spring there is an increased flow of blood to the buck's head, certain of the arteries of that region enlarge, and the budding horns appear. These are covered with a hairy skin—the *velvet*—rich in blood-vessels, and so rapidly does the formative work proceed that in about ten weeks the antlers of a full-grown stag, weighing over twenty pounds, are complete. When growing, they are warm to the touch and exceedingly sensitive—the reindeer, it is said, suffering terribly from the clouds of gnats which settle upon

its growing horns. When full grown, the supply of blood is gradually cut off by the burr which forms round the base of the horn; the *velvet*, shorn of its vitality, begins to peel off; the once super-sensitive antlers lose all feeling; and the creature comes forth to display, and if necessary to do battle with, its antlers for the possession of the hinds.

At this season the larger male deer are truly formidable creatures: the elk, for example, will attack any animal—man not excepted—that comes in its way; and even the red deer has been known to beat off a tiger with its antlers. The rutting season over, he again retires, when the attachment of the antlers to the skull gradually loosens, and those ensigns of love and war fall off.

Shed antlers, it might be supposed, would, as annual productions, be not uncommon objects in deer districts. The reverse, however, is the case, and the question has frequently been asked, What becomes of stags' horns? That they are not over-looked may be regarded as certain; while it is the universal opinion of Highland gillies that they are not found because the deer themselves eat them. A ready supply of the calcareous matter necessary for the upbuilding of future antlers would thus be obtained, just as the barn-door fowl is fain to eat its empty egg-shells in order to obtain the lime for future eggs.

There is little or nothing against this theory

beyond the supposed unfitness of ruminant teeth to comminute so hard a substance; but cows are said to be fond of gnawing bones, and if so, deer need not be unfit to eat antlers. We have walked over the deer districts of Arran for weeks, and only once came upon a trace of a shed antler—a piece several inches long, with the burr end intact, while the other bore evident marks of having been gnawed.

Deer, however, have been actually seen so engaged. Mr. Williamson, a noted Scottish sportsman, states, in his recent work on "Sport and Photography in the Rocky Mountains," that in Lewis he has seen hinds chewing the stags' antlers; and, according to Scrope, a late Duke of Atholl once found a dead hind which had been choked by a part of an antler that remained sticking in its throat.

The habit of thus utilizing their shed horns is probably more or less common to all species of deer. Sportsmen who have hunted over the "barren grounds" of North-East America, frequented by thousands of reindeer, have remarked upon the exceeding fewness of the shed horns they have met with—a circumstance all the more remarkable from the fact that in the reindeer alone, of all the deer tribe, the female as well as the male bears antlers.

Those discarded weapons are, however, sometimes met with in unexpected abundance. Thus, in the early days of American colonization, "Stags' Prairie" owed its name to the vast pyramid of antlers which

which fell to Mr. Williamson's rifle on the Rocky Mountains, the largest pair of antlers measured fifty-six and fifty-nine inches respectively, with a girth at the base of about fifteen inches, and with tines — sixteen in number — too thick in some instances to be clasped by a man's hand. These must have weighed upwards of sixty pounds, and yet this immense mass of bone was the growth of only ten or twelve weeks. The antlers of the wapiti do not, however, usually weigh more than from twenty to thirty pounds.

The largest of living deer is the elk or moose, which is higher at the shoulders than a horse. It inhabits the northern parts of both Europe and America. Its antlers are not cylindrical like those of the wapiti, but palmated, the palm being sometimes twenty inches across, and giving off numerous branches. They have been known to weigh sixty pounds, and to have an expanse from tip to tip of nearly six feet. In spite of such wide-spread encumbrances, the elk is so careful as it passes at leisure through a forest that it will not even touch a twig with its antlers. In moving along, it raises its nose high in the air, so as to lay its horns back horizontally; a position, however, which has the disadvantage of preventing the elk from seeing the ground distinctly, and thus causing it frequently to stumble. On this account the ancients supposed it to be the victim of frequent attacks of epilepsy. Its remains,

found in several parts of Scotland, prove the elk to have been an inhabitant of Britain.

A much larger species of deer co-existed with it —namely, the gigantic Irish elk, whose head-quarters, to judge from the abundance of its remains, would appear to have been in Ireland. It is probable, however, that the "sister isle" had at that time a land connection with Britain, a relic of which remains in the equidistant Isle of Man. The first tolerably complete skeleton, indeed, of the Irish elk—the one figured by Cuvier—was a Manx specimen, and is that which now forms a conspicuous object among the fossil treasures of the Edinburgh Museum. In the proportions of its antlers this extinct elk exceeds all known deer, the antlers of the largest known specimen measuring each seven feet along their curve, the palms being thirty inches broad, their weight about eighty pounds, and their tips eight feet apart.

The red deer, the roe, and the fallow deer are the tiny representatives in Britain at the present day of the antlered tribe, which in comparatively recent post-tertiary times included the Irish elk, the moose, and the reindeer.

the wound so tight as to prevent the further passage of the blood into the system, thereafter sucking and cauterizing the wound.

These methods, however, are only effectual when applied at once, and it can be readily understood how seldom the bitten person is likely to have the necessary appliances at hand, or the presence of mind, even if he had these, to make immediate use of them. How quickly they must be applied if they are to be of any use was shown by Sir Joseph Fayrer's experiments on dogs and domestic fowls. Thus a dog bitten on one of its limbs by a cobra had a ligature as tight as two men could pull it applied five seconds after; yet the subtle poison had already outrun them, and the creature died eleven minutes after being bitten. These experiments also proved that the blood of a poisoned animal itself becomes poisonous, the venom having been thus transmitted through the bodies of three successive animals with fatal effect.

Snake-bite being thus practically incurable, the Indian Government has for many years been carrying out the extirpation policy which, under the guidance of St. Patrick, so effectually cleared the "sister isle" of its snakes. Unfortunately these creatures multiply rapidly; their numbers, however, being kept somewhat in check by a host of natural enemies. The jungle fowl devour their eggs, and the stately adjutant and several other birds feed

upon their young, Their worst enemy, however, is the mongoos—a weasel-like animal, which boldly attacks and overcomes the largest cobras. This creature was until lately believed to be proof against snake-poison. It is now known not to be so; and that it does not die of snake-bite is simply because in its encounters with those reptiles it takes care not to be bitten. How it effects this is thus graphically described by a recent spectator of one of those fights: "The moment the mongoos sees his enemy, his whole nature appears to be changed. His fur stands on end, and he presents the incarnation of intense rage. The snake invariably attempts to escape, but finding it impossible to evade the rapid onslaught of the mongoos, he raises his crest and lashes out fiercely at his little persecutor, who seems to delight in dodging out of the way just in time. This goes on until the mongoos sees his opportunity, when like lightning he rushes in and seizes the snake with his teeth by the back of the neck close to the head, shaking him as a terrier does a rat. These tactics are repeated until the snake is killed." The Government of India could find no better allies than those lithe little mammals in their crusade against venomous snakes, and their increase throughout the infested districts ought by all means to be encouraged.

At present money rewards are offered for the capture and destruction of such snakes, and during

men, in whose nets they are sometimes caught, and from which they pass unnoticed along with the fish into the boat. Should they be touched or trampled upon, these timid animals use their fangs with fatal effect. Few of them are larger than the British viper, and all of them are modified in form to suit the medium in which they live. Thus the tail is flattened like a paddle to aid them in swimming, and their eyes are useless when out of the water. The deadliness of their poison is seen in the fact that they are the only snakes whose bite proves fatal to other poisonous serpents.

Snakes are so generally regarded as venomous that it may surprise many to learn that the vast majority of them—the proportion being six to one—are innocuous. It is now also known that the possession of a special poison apparatus is not confined to snakes among back-boned animals, but is found also in certain fishes, only in these the poison is not conveyed by means of a tooth or fang, but through a spine. Dr. Günther of the British Museum lately described a fish found in Central America, the dorsal spines of which exactly resembled in structure the fang of a venomous serpent, each having at its base a sac, in which the venom is secreted, and from which it is injected into the wound. A still more dangerous fish is said to occur in Mauritian waters, the thirteen spines of its dorsal fin being each connected with a poison-bag at its

base, and having each a pair of grooves along which the poison flows. Fatal results are said frequently to follow the incautious handling of this fish, although the poison appears to be less rapid in its action than is the venom of snakes.

The nearest approach to venomous fish among the natives of British waters is found in the sea-dragons or sea-spiders occurring on many parts of our coast. These are supplied with a long sharp spine on each of the gill covers, with which they can inflict a wound so painful as to suggest the presence of poison. Fishermen are as careful in touching these weevers—as they are usually called—as their Hindu brethren are when handling the deadly sea-serpents occasionally taken in their nets.

If a few fish are thus venomous when living, a much larger number are poisonous when dead. Lately a project was set on foot for the purpose of bringing fish in a frozen state from distant parts to France, when Dr. Heckel of Marseilles drew attention to the danger that might arise from the importation of poisonous fish. These are specially abundant in warm seas, and include all those spiny, balloon-shaped fish known as diodons and tetraodons, the whole tribe of trigger-fish (or "old wives," as they are called from the feebly shrill sound which they emit), and the numerous species of trunk-fish. Some of these, it would appear, may be eaten with safety, if certain parts be entirely removed; such

III

BLIND ANIMALS.

To the vast majority of living creatures there can scarcely be a greater misfortune than that of blindness. Yet there are very many species of blind animals known—and recent deep-sea explorations have added considerably to their number—whose want of vision cannot be considered as entailing any disadvantage, while in some cases it may even be regarded as a gain.

Among the lower forms of animal life there would seem to be some relation between locomotion and the power of vision, creatures leading a roaming life being usually possessed of well-developed eyes, while others, higher in the scale of organization, but sedentary in their habits, are either eyeless or have the organs of sight imperfectly developed. This is specially observable in those creatures which in the early stages of their existence are free-swimming and active, but which afterwards fix themselves permanently to some solid object, as in the case of

barnacles. These, in the young state, move about freely in the water, and possess well-developed eyes. On reaching maturity, however, they fix themselves for the remainder of their lives to rocks, which they cover as with a coating of rugged bark, at the same time losing entirely their organs of sight.

It would be difficult to understand how an animal thus fixed to one spot could be benefited by the possession of visual organs; for the mere sight of food which it could by no possibility reach would be no advantage. These and other creatures similarly situated are accordingly provided with long arms or tentacles, in some cases furnished with stings, which they wave about in the water in search of passing prey.

Light, however dim, is essential to vision, and there are many species of animals whose total blindness is to be accounted for by the total darkness in which they live. Eyes are of no use to the mole as it rushes along its subterranean galleries, while, owing to their liability to injury, they would be actually detrimental to it in its burrowing operations. The eyes of the British mole have accordingly, through disuse, grown so small as scarcely to be perceptible, while those of the mole found in Southern Europe are wholly covered over with skin and fur.

Although nature's law of parsimony thus leads to the gradual obliteration of an organ no longer

the eyes of which are found to be in various stages of obliteration.

There is the blind fish (*Amblyopsis*), in which the eyes appear to be totally gone, which also occurs in the equally extensive but less known Wyandotte Cave in Indiana, where it was recently obtained by Professor Cope. He found that those blind fish, when not alarmed, came to the surface to feed, and swam in full sight "like white aquatic ghosts." Being perfectly blind, they can be readily captured with the hand, provided the most perfect silence is maintained. Their sense of hearing, says Professor Cope, is evidently very acute, for at any noise they turn suddenly downward and hide themselves beneath stones in the bottom.

Equally interesting are the blind cray-fish of these caves, in which, as Darwin remarks, the foot-stalk for the eye remains, though the eye is gone. "The stand for the telescope is there, though the telescope, with its glasses, has been lost." It is significant, however, of the mode of origin of those blind crustaceans that in the young the eyes are distinctly visible. Those American caves likewise contain several species of blind beetles, spiders, shrimp-like creatures, and centipedes.

The largest cave in Europe is that of Adelsberg in Carniola, and this has supplied naturalists with a considerable number of eyeless species—the most remarkable of these being the proteus, an amphib-

ian, about a foot in length, of a pale, ghastly colour, and having its rudimentary eyes covered over with skin.

The recent investigations into the fauna of the deep seas have also disclosed the fact that the caves of ocean contain sightless animals. At depths varying from a few hundred to nearly two thousand fathoms, the *Challenger* dredge brought up several species of stalk-eyed yet eyeless crustaceans, no trace of the stalks even on which the eyes are placed remaining.

The darkness at such depths must be profound, and that it is the cause of blindness in those abyssal creatures would appear from a remarkable instance narrated by Sir Wyville Thomson of a crustacean, specimens of which, taken in shallow water, were found to have well-developed eyes; while others, taken from a depth of one hundred and ten to three hundred and seventy fathoms, had only the eye-stalks, the eyes at their ends being replaced by round calcareous knobs; while in others, still of the same species, obtained from a depth varying from five hundred to seven hundred fathoms, the eye-stalks had completely changed their character, being no longer movable, and their terminations being joined together so as to form a pointed rostrum. Strange to say, however, at equally profound depths other crustaceans were brought up in which the eyes were unusually well developed, and "apparently

of great delicacy." This would seem to show that deep-sea existence, in what must after all not be absolute darkness, does not necessarily extinguish the organ of vision; whether it shall do so, or whether the eye shall, as in the owl and other nocturnal animals, become adapted to the comparative darkness, depending probably on a great variety of circumstances. "Is it possible," says Sir Wyville Thomson, "that in certain cases, as the sunlight diminishes, the power of vision becomes more acute, until at length the eye becomes susceptible of the stimulus of the fainter light of phosphorescence?"

During recent dredgings in the Caspian Sea, Dr. Oscar Grimm discovered a large number of new species of crustaceans, many of which were either blind or had defective organs of vision, while at similar depths he found other species, the large convex black eyes of which he says "certainly absorb a sufficiency of light even in the darkness of the depths." He, however, found that in the case of the blind species the eyes were replaced by other highly-developed sense organs.

On the theory that each species of animal has been separately created, all the blind forms found in caves and ocean depths must be regarded as having been created blind. Probably in no case, however, can it be said that the rudiments of eyes are entirely awanting, while in the young, and especially in the embryo, they are usually much more

apparent. The special creationist is therefore bound to give some reasonable explanation of the presence in creatures destined to live in total darkness of those useless rudiments. This, it cannot be said, has yet been done; meanwhile the evolution hypothesis offers the explanation that those rudimentary eyes are the result of the disuse of those organs through the long residence in darkness of a succession of creatures which originally entered on a subterranean life in the full possession of eyesight. In short, the *absence* of rudimentary organs in animals would, we venture to say, be about as fatal to the doctrine of evolution as their *presence* undoubtedly is to that of special creation.

On the theory that those blind animals are the modified descendants of species which once lived above ground, it might be expected that, in some cases at least, they would show affinity with forms now inhabiting the surrounding country; and this has been shown to be the case. A few, however, as the blind fish and the proteus, are exceedingly anomalous; but it is not too much to suppose that the ancestors of these, having been beaten in the struggle for existence, died out, while those of their number which betook themselves to the caves have survived, owing to the less severe competition there encountered, just as the remnants of conquered nations have sometimes succeeded in maintaining their separate existence and independence by retiring to their mountain fastnesses.

IV.

SOME ANIMAL DEFENCES.

THAT the struggle for existence throughout the animal kingdom represents a perfectly normal state of affairs, seems evident from a consideration of the number and the variety of the weapons with which nature has armed her children for the battle of life. Horns and tusks, stings and fangs, pincers and claws, spines and spurs, each plays its part in the strife: some owing their efficiency, like the club of the savage, to the brute force with which they are wielded; others, like the guns of civilized man, to the material with which they are loaded.

These, however, by no means exhaust the animal armoury; and attention has lately been directed to one of the most interesting of the other modes of defence exemplified in the case of the bombardier beetles, which, as will be shown, is widely prevalent under various modifications throughout the animal kingdom. Those beetles, when pursued, discharge from behind a highly volatile fluid, which no sooner

reaches the atmosphere than it explodes, producing a puff of pungent smoke, which serves to cover their retreat, while momentarily disconcerting their pursuers. A single volley of this liquid explosive does not, however, nearly exhaust their ammunition, as they continue at short intervals during their retreat to frighten and mislead the advancing foe by the din and smoke of their tiny artillery. The vapour has a very pungent scent, exceedingly irritating to the delicate surface of the eye, while its action on the skin is said to resemble somewhat that produced by nitric acid.

A few other insects are believed to be similarly provided with explosive mixtures, while a very large number are known to be defensively armed with offensive odours. Others, again, as the female glow-worm, the fire-flies, and the lantern fly, emit light instead of scent, and many naturalists believe that in the luminous phosphorescent halo with which they are surrounded at night, these insects have been provided by nature with a means of defence as effective as is the circle of fire with which travellers scare away the beasts of the forest from their nocturnal encampments.

Although the power of emitting offensive liquids and vapours, as a means of defence, occurs more commonly among insects than anywhere else in the animal kingdom, it is not unknown among other and higher groups. Thus the toad emits a poisonous

secretion, which, according to Darwin, causes the mouth of a dog to froth as if attacked by hydrophobia, and when applied to a delicate skin produces slight inflammation. The toad's secretion has likewise an offensive odour, and hence, no doubt, its greater immunity, as compared with the frog, from the attacks of carnivorous animals.

This weapon, however, may be said to have reached its greatest perfection in the small badger-like animals known as skunks, which abound in various parts of America. These are provided with glands which secrete a yellowish liquid possessing a fetid odour of the most penetrating and persistent description. When threatened with danger, the skunk squirts this liquid towards its assailant to a distance varying from four to fourteen feet, according to the strength and freshness of the creature—an emission which is generally sufficient to cause man, dogs, and all other animals to beat a hasty retreat. "If," says Darwin, "a dog is urged to the attack, its courage is instantly checked by a few drops of the fetid oil, which brings on violent sickness and running at the nose."

The discharge is said to be invisible by day, but, according to Coues, it possesses a certain phosphorescence which renders it luminous by night. Whether seen or not, this powerful secretion is said to make itself felt nearly a mile away; while its *staying* powers are such that, according to Audubon, the

place where a skunk was killed in autumn was still strongly odoriferous after the disappearance of the snow in the following spring. Should the luckless hunter come within range of this scent-bearing syringe, it is almost impossible by any amount of washing to rid his garments of the taint; for even when at last supposed to be gone, exposure to bright sunshine or to the heat of a fire is said to revive it. Of late years, however, furriers have so completely succeeded in removing all traces of scent from the skin of the skunk that these are now largely used for ladies' apparel.

Intolerably disagreeable to the nose, the glandular secretion of the skunk is also dangerous to the eyes—dogs, it is said, being not infrequently blinded by the discharge; while Sir J. Richardson states that he knew numerous instances of Indians who had been deprived of their sight through inflammation caused by contact with this liquid.

On the other hand, it has, according to Coues, been put to medicinal use, especially in asthma, and apparently with good effect, although many would be inclined to regard the remedy as scarcely better than the disease. That the benefit of one individual is liable, under such circumstances, to cause annoyance to many, would seem to have been forcibly illustrated in the case of an asthmatic clergyman, who procured the glands of a skunk, and had them tightly corked in a smelling-bottle. Rejoicing in

his new-found specific, he on one occasion uncorked his bottle in the pulpit, and—drove his congregation out of church!

The efficiency of this defensive weapon is plainly seen in the appearance and disposition of the skunk. It has neither the sombre protective colouring, the intelligence, nor the agility of its congeners; nor does it want them. Fearing neither man nor beast, all of whom give it a wide berth, it needs no concealment, and therefore conspicuous colouring is not with it, as it is with most other animals, a source of danger. Hence, also, as Coues shows, "its heedless familiarity, its temerity in pushing into places which other animals avoid as dangerous, and its indisposition to seek safety by flight."

The peccaries of the same region have a gland situated on the back, the secretion from which possesses an odour less intense, though not much less offensive, than that of the skunk, and which is likewise defensive. The peccary's flesh, however, is eaten by the native Indians, who, on killing it, immediately cut out the glandular part, so as to prevent the odour infecting the whole carcass.

Among mollusks there are several examples of the use of this method of defence: thus those soft-bodied forms known as *sea-slugs* and *sea-hares*, when irritated or alarmed, emit a reddish-purple fluid, which so colours the water for some distance around as effectually to conceal their whereabouts

from their enemies. There are also several shell-fish found in the Mediterranean which have this power; and it was from one of these that the celebrated purple dye of the ancients is supposed to have been obtained.

The best example, however, of the use of this weapon among mollusks is to be found in the cuttle-fishes. These possess what is known as the *ink-bag*, the contents of which were formerly used for writing and in the preparation of *sepia*—a substance named after one of those creatures. When the cuttle-fish is menaced with danger or otherwise irritated, it shoots out a quantity of its inky ammunition, and under cover of the dusky cloud thus produced it seeks a hiding-place. "I had followed," says a recent observer, "one of these animals to a small hole in a rock. In vain I solicited him to come out by gentle pulls with a boat-hook; at last, when they were harder than he liked, he discharged the contents of his sepia bag all over me, and spoilt my waistcoat and trousers completely—that dye requiring no mordant, and being, as far as I know, indelible."

The most remarkable of all the defensive discharges of animals, however, remains to be noticed—namely, that possessed by about a dozen species of fishes of communicating to other animals an electric shock. For this purpose they are armed with regular galvanic batteries, each of the pair in the

torpedo fish consisting of about four hundred and seventy hexagonal prisms, supplied altogether with more than two hundred nerves. The electric currents generated in those natural batteries behave exactly like currents artificially produced—Günther stating that "they render the needle magnetic, decompose chemical compounds, and emit the spark." As in a galvanic battery, also, it is not sufficient to touch the fish at one point only in order to receive the shock; the circuit must be completed by contact at two points, either directly or through the medium of some conducting body. Thus, according to the same authority, a painful sensation is said to be produced by a discharge conveyed through the medium of a stream of water.

The most powerful of those fishes is the electric eel of the marshes and rivers of Brazil and Guiana, which possesses an electrical apparatus sufficient, it is said, when advantageously disposed, to paralyze the largest animals. Most people are familiar with Humboldt's graphic description of the Indian method of capturing those creatures—namely, by driving the wild horses of the surrounding plains into the streams, and keeping them there until the eels, by frequent shocks, have exhausted their stored-up electricity upon them, when, becoming even more helpless than other fishes, they are readily captured. Recently, however, considerable doubt has been thrown upon

Humboldt's narrative, owing to the fact that subsequent travellers have failed to discover any trace of so unique a method of fishing.

Three electric cat-fishes occur in the tropical rivers of Africa, one of these—the Nile species—being known by the Arab name for *lightning.* The other electric fishes are rays, of which the "torpedo" of the Mediterranean is the best known. It is less powerful than the electric eel, but large individuals are able, by a single discharge, to disable a man; they are therefore dangerous to bathers. The discharge is dependent on the will of the fish, and is put forth in self-defence or to stun its prey. Should one shock prove insufficient for this purpose, others follow in rapid succession, until the object is attained, or their store of electricity exhausted. In the latter case, rest and food are necessary to the recharging of their batteries.

V.

ANIMAL FOES.

In the constant struggle for possession of our common mother earth, man is not uniformly victorious over the lower animals. The strength of the tiger, it is true, is no match for human skill and cunning; nor can even the serpent, that deadliest if not subtlest beast of the field, hold its own against man in any quarter of the globe. The only creatures that have the slightest chance in this struggle are those which individually are the weakest and most insignificant. It is not the lion and tiger among mammals, but the mouse and the rabbit, which thus compete most successfully with the human race—a fact which lately received forcible illustration in the plague of mice which visited Bohemia and destroyed the crops, while the inhabitants could do little more than look on and see their hopes of a harvest blasted. Much more formidable foes than either of those feeble rodents are, however, to be found among a class of still more insignificant creatures—namely, insects

which, over certain areas of the earth's surface, take man's place as "lords of creation." There are districts in South America from which man has been driven by the ant, and there are many parts of Africa where the tsetse fly practically excludes him, by allowing neither his oxen, horses, nor dogs to live.

Although such extreme cases are rare, and occur only in tropical climates, yet man in all parts of the world is ever and anon reminded of the enormous collective power of insects by the injuries they periodically inflict on the produce of his fields. The most painful experience of this kind that has probably occurred in Europe during the present century is that of the vine disease. This disease was first observed in the year 1865, in the neighbourhood of Avignon; but a considerable time elapsed before its cause was discovered in the presence on the vine of an almost microscopic insect—*Phylloxera vastatrix*, a member of the family of plant-lice. This insect was known as parasitic on the vine in America at least a dozen years before its presence was detected in Europe, and it is generally believed to have been introduced on certain vine stocks imported from America by a wine-grower in Bordeaux.

The phylloxera, which when full grown does not exceed one thirty-third of an inch in length, infests chiefly the rootlets of the vine, fixing its needle-like proboscis into them, and thus diverting the juices

from their proper function of nourishing the plant. It multiplies exceedingly, especially during the months of August and September, when the close aggregation of its minute individuals produces large yellow spots, which sometimes coalesce, so as to form a continuous yellow sheath of living parasites around the root fibres.

It reproduces itself in a variety of ways, and, according to the most recent investigations, gives origin to at least four forms, each of which is believed to mark a stage in its development. There is first the wingless form, which lives all the year round among the vine roots, and gives birth in the summer to a few winged females. These, making their way to the surface, take wing to "fresh fields and pastures new," where they convey the disease by depositing their eggs on the vine leaves. These eggs produce the true sexual form of phylloxera, each of which, in turn, deposits a single, impregnated egg beneath the bark of the vine. There it lies undeveloped during the winter, giving origin, however, in spring to a fourth form, which produces galls as large as peas on the under surface of the leaves, and is chiefly obnoxious as being the parent of the root-form with which the series began, and which is the great enemy of the vine.

The work of destruction is somewhat gradual in its progress. During the first year of the attack the disease betrays its presence only by slight swellings

on the upper rootlets, while the production of fruit is rather increased than diminished. During the second year the plant, under the double duty of nourishing itself and its parasite, looks sickly, but still bears fruit. Next season it is evidently dying; and in the fourth year it is dead. As the plant gets exhausted, its relentless foes begin to desert it—hurrying from its roots, like rats from a sinking ship, to the nearest healthy vine. It is thus invariably observed that the dead plant is entirely free from phylloxera.

The great majority of those insects are wingless, and as they are unable to burrow, they make their way from vine to vine along the minute interstices of the soil, the possibility of doing so depending altogether on the nature of the ground—clayey soil, which readily cracks when dry, affording the surest passage, while a sandy soil is for them practically non-conducting.

That the character of the ground in this respect has an important influence on the spread of the disease, is shown by the fact that the vines in the south of France are healthier or the reverse according as the soil is more or less clayey. When insuperable obstacles block their progress beneath, they attempt to make their way along the surface, where, however, under the influence of air and sunlight, they are in imminent danger of perishing through desiccation. They prefer the tender succulent roots

near the surface, and only descend deeper when these are no longer available. Old vines, whose roots go deep down, thus survive the attacks of phylloxera much longer than the young, whose rootlets are near the surface; but whether young or old, the rule undoubtedly is that once attacked their ultimate destruction is inevitable.

The disease, since its first detection in France, has spread with alarming rapidity. In the beginning of 1877 twenty-eight departments were infected in a greater or less degree; while at the end of 1878 the number had increased to thirty-nine. The phylloxerated departments then formed two divisions entirely separate from each other—the one occupying the valley of the Rhone, the other the valleys of the Garonne and Dordogne. During the past year (1879), however, they have become united, and now the infected region stretches right across the southern half of France from the Bay of Biscay to the Mediterranean. Already nearly a million of acres of vines are all but destroyed, while half a million more are in imminent danger. In the department of Charente-Inférieure, out of a total of four hundred and twenty thousand acres of vines, only about thirty-six thousand remain unaffected, while its increasing scale of growth is seen in the fact that while sixty-two thousand acres were freshly attacked in 1877, fully eighty thousand were invaded in 1878.

The ravages of this formidable insect are, however, no longer confined to France. It has appeared in almost every wine-growing country in Europe, having been introduced, it is supposed, with vine stocks imported from infected districts in France. In spite of the intervening Alps and Jura, it crossed into Switzerland, and appeared in the neighbourhood of Geneva. In Spain it is said to have occurred at more than a hundred points, and in Portugal it is beginning to do serious mischief in the district of the Douro. Its appearance has also been recently noticed in Italy, in Austria and Hungary, in the German Empire, and in Greece, although in none of these, except perhaps in Spain and Portugal, has it yet done much damage.

Forewarned by the rapidity of its progress in France, those countries had time to forearm themselves; and by the Convention of Berne in 1878, to which the wine countries of Europe were signatories, the most stringent rules as to the introduction of vine stocks into those countries, and as to the methods of dealing with the first appearance of the plague in new localities, were adopted.

The French Government long ago offered a reward of three hundred thousand francs for the discovery of a simple available remedy for the vine disease; but although about one hundred and forty such have, it is said, been proposed, not one of them can be regarded as nearly satisfactory, the best of them being merely

palliatives by which the life of the vine may be somewhat prolonged.

Perhaps the most satisfactory of them, where it can be readily applied, is submersion during autumn or winter for forty or fifty days, with subsequent manuring. Such a method, however, is only applicable for level vineyards in the neighbourhood of a copious water supply. Another method recommended by the various commissions which have dealt with the subject is the injection of sulphocarbonate around the roots. Considerable skill, however, is necessary in applying this, as an excess of the mixture is as fatal to the vine as to its parasites. This method is too expensive for general application, but has been tried with good results in districts producing high-class wines.

Outside of France the phylloxera has been in several cases kept at bay by the application of the stamping-out process. This was done some years ago in Switzerland, when the diminutive monster was discovered in a vineyard at Chambery, the vines being destroyed root and branch, and the ground sown with quicklime. The disease has not since reappeared in that neighbourhood, nor in any of the contiguous cantons; these, however, are now so surrounded by phylloxerated country that no confidence is felt in their continued immunity unless by being prepared to carry out the same drastic policy whenever the

phylloxera appears. For this purpose several of the cantons have imposed a vineyard tax, in order to raise a fund to compensate owners for the compulsory destruction of their vines should they become infected.

Although the European phylloxera is in all probability merely the New World form imported, American vines attacked by the phylloxera do not succumb to the disease; and many French wine-growers are now advocating the replanting of the vineyards with the best resisting American varieties, or of grafting the latter on their own. The superior resisting power of the American vines has, however, been recently attributed to the fact that they are allowed to grow to some height, whereas in France they are cut down every year within a few inches of the ground—a system which is supposed to produce such over-stimulation of the root as causes it to fall an easy prey to the phylloxera. As the growth of the vine beyond its present stature is believed to interfere seriously with the quality of the wine, the introduction of the American varieties might, according to this view, be but a dubious benefit. In districts where the disease has already done its worst, the latter have in some cases been planted; but the plantations thus formed are too young to furnish conclusive evidence either as to their resisting power or as to the quality of the wine which they may yield.

Science, aided by the State, has more than once come to the aid of the French agriculturist and manufacturer in discovering remedies for diseases which threatened the existence of important industries, and that it will yet succeed in finding a means of checking the ravages of phylloxera is at least probable. Meanwhile the condition of extensive tracts of country in France, owing to the failure of this staple industry, is truly deplorable. "From the tops of the hills all along Floirac, Loussiac, and St. Croix," says a correspondent of the *Times*, "you see large barren fields, lifeless houses, props without vines clinging to them, unrepaired and unfrequented roads, peasants engaged in a hopeless labour."

While a European Congress was sitting upon phylloxera, a United States Commission was busily investigating that greatest insect scourge of North America—the Rocky Mountain locust. Their report has since appeared, and from it we learn that the locust area comprises nearly two millions of square miles in the states and territories to the west of the river Mississippi, and that its devastations entail a loss of about fifty millions sterling annually.

The account of its ravages furnished by witnesses throughout the Far West shows that the American plague of locusts is in no way inferior to similar visitations which have at times devastated various parts of the Old World. Impelled chiefly by the

desire for food, the locusts migrate from the permanent home of the species in the elevated plains among the Rocky Mountains, and fly, usually at a great altitude, in enormous swarms—one witness stating that he had seen them "cover in the sky, east and west," a space which he estimates as "twenty or thirty miles wide," moving in a body half a mile deep, and consuming about two hours in passing.

Their destination is the fertile plains to the west of the Mississippi, where they are sometimes visible twenty miles off, presenting as they roll on the appearance "of dense clouds of smoke, like that of burning prairies," and so closely packed together as to darken the sun like an eclipse at mid-day. The noise of their wings is heard like the rattling of cars, and when they have fixed on a spot for settling, they descend like huge flakes of snow, literally covering the face of the earth.

They invariably bring with them an omnivorous appetite, which they immediately prove by devouring first the cereal crops, thereafter all living plants, and last of all such incongruous materials as paper, cotton, and woollen stuffs, and even the dead bodies of animals. The female also takes the opportunity of depositing her eggs, placed in little packets, each containing thirty, in holes about an inch beneath the surface. What a "progeny of woe" is thus left behind may be gathered from the fact

that a single square foot of ground, taken at random in a field where the locust had been thus employed, contained three hundred of those egg-packets, which would give nearly four hundred millions of eggs per acre.

It is a remarkable circumstance in their life-history that the young hatched in those visited areas have a tendency to return to the region whence their parents came. That they ever leave what is thus their true habitat is believed to be due to the unusual abundance of the species during certain years which, from excessive heat and drought, are specially favourable to the development of insect life.

It is hoped that by means of the highly efficient Weather Signal Bureau of the United States the periodical invasions of the locust may yet be predicted with considerable certainty, and by thus fore-warning, there is no doubt that much could be done to forearm, the farmers of the West against this very considerable "fly in the ointment" of their prosperity.

Unlike most other insect plagues, the locust has considerable economic value, as it forms a highly nutritious food, and the Commission evidently think that in lieu of entire quittance, of which there is no present prospect, the most should be made of this immediately available asset. The young, it is said, when boiled form a broth scarcely distinguishable

from that made with beef, while the adult bodies, which, whether roasted or fried, form an agreeable food, might be ground and compressed into a "preserved meat."

Although, since its removal from the list of game, the rabbit has ceased to play the prominent part it once did in British politics, few animals have in their time given more trouble to governments and commissions. This is entirely owing to its unfortunate prolificness, which is such that a single couple of rabbits will in four years increase, at a moderate computation, to a total of two hundred and fifty thousand. It was on this account that, at the beginning of the Christian era, the inhabitants of the Balearic Islands implored the Roman Emperor Augustus to send an army to exterminate the rabbits, as there was no longer room for both them and man.

It would have been well had our Australasian colonies studied such historical precedents before adding the rabbit to the other *home* animals with which it has been their delight to surround themselves. Half a century ago it was introduced into Tasmania, and already thousands of pounds have been spent, and the expenditure will have to go on, not in getting quit of it—for the most sanguine can scarcely hope for this—but merely in keeping its numbers within reasonable bounds.

The rabbit has likewise been introduced into New

Zealand, with results even more disastrous than those in Australia, these making themselves apparent in a diminution of the number of lambs and in the quantity of wool produced. Government has had to take up the question, and where landlords neglect to abate the rabbit nuisance, the local authority has power to intervene and carry out the necessary measures at the public expense, while still more recently an Act has been passed authorizing the Government to offer a bonus for every rabbit skin sent out of the colony.

The nuisance which this rodent has become in Australasia is due not only to the sparseness of the population, but also to the absence or great scarcity of carnivorous animals. The presence of large numbers of the smaller carnivora, as dogs, cats, weasels, etc., would probably do more to abate the evil than the present poisoning system of New South Wales, or even the bonus system of New Zealand.

VI.

ANIMAL PARTNERSHIPS.

THE saying, that "big fleas have little fleas upon their backs to bite them," expresses with regard to a particular case what is true of the whole animal kingdom; for in the matter of parasites it is true of most animals that they are a host in themselves. This is a somewhat ugly fact which Nature has to hide, and it must be confessed she hides it well; for, as a rule, the host is neither conscious of, nor incommoded by, the presence of his numerous guests. A less intimate but more pleasing connection subsisting between different animals is that known as *commensalism;* commensals being creatures which may be said to sit at the same table, but which do not prey upon one another.

Of late years naturalists have become acquainted with numerous examples of this form of animal partnership; and lately a fresh instance occurring where they seem to be rarest—namely, among the higher animals—was recorded. In one of the

Chicken Islands, off the New Zealand coast, lately visited, a curious lizard, known as the tuatara, and certain species of petrels, were found inhabiting the same burrows, apparently on the best of terms. In rare cases the burrow, which consists of a passage two or three feet long, ending in a chamber one foot and a half long, one foot broad, and six inches high, is the work of the bird; as a rule, however, the lizard is the excavator. Each builds its nest on opposite sides of the chamber, the lizard almost invariably choosing the right and the petrel the left side. The former sits with its head close to the entrance, so as to defend it; and if a hand or a stick be inserted into the passage, the creature bites at it furiously. The tuatara feeds partly on worms and beetles, and partly on the remnants of fishes and crustaceans brought to their common table by the petrel—both animals being thus benefited by the copartnery.

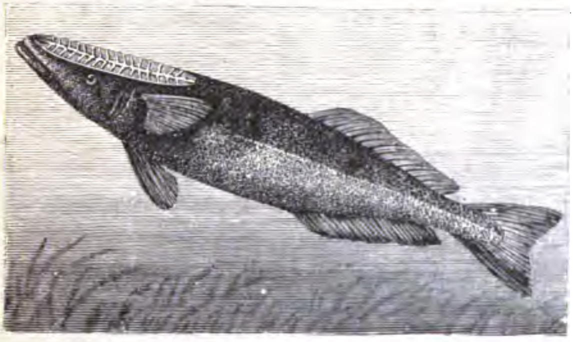
So much probably cannot be said of the prairie dog, whose underground home on the plains of North America is frequently shared by the rattlesnake and the burrowing owl. These were at one time supposed to form a "happy family," but considerable doubt has been cast on the point by the discovery of young prairie dogs in the stomach of the rattlesnake. In certain parts of South America the rabbit-like viscacha has a messmate in a little burrowing owl, which is thus saved the labour of

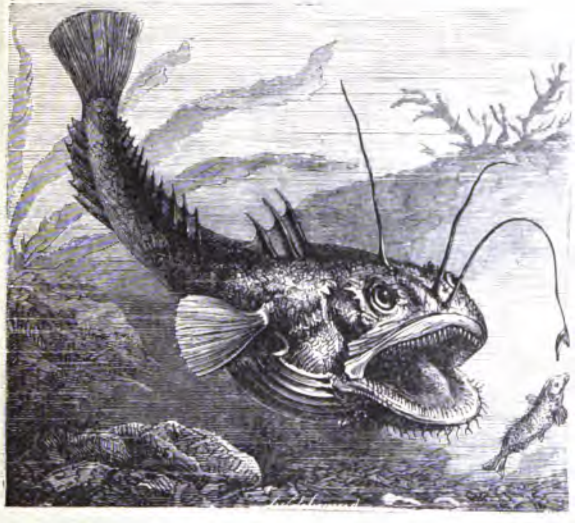
excavating a home for itself; but in Banda Oriental, where the viscacha does not occur, the owl has to do its own burrowing.

Among insects a few cases of commensalism are on record, but the first known instance of its occurrence among caterpillars was recently recorded by Fritz Müller. He found two caterpillars in Brazil living on the leaves of the mulberry. The larger one was protected by a covering of long stinging hairs or thorns; and, like most caterpillars similarly protected, its colouring was exceedingly bright and conspicuous. The other, a small blackish form, sat across the back of its gaudy partner, enjoying the protection afforded to both by the surrounding stinging hairs. On removing the smaller caterpillar from its retreat, Müller found that it made its way back again as quickly as it could. Under an anæsthetic administered to it the larger caterpillar died, and its hitherto attached friend was then observed to leave it, and to make its way to the back of a living specimen.

It is among marine animals, however, that the phenomenon of commensalism has been most frequently observed. The remora is a feeble fish, little able to make its way alone in the world of waters, yet there are few fishes which have a wider distribution. It owes its success in life to the powerful alliances it forms. One of its fins has been transformed into a sucker, placed right on the top of its

THE REMORA.





THE ANGLER, OR FISHING FROG.

head, by means of which it attaches itself firmly to any passing shark, whale, or even ship—no doubt taking the vessel for some huge sea-monster. By these it is transported, without further exertion on its part, over great distances, meanwhile picking up such food as may come in its way. According to Beneden, the fishermen of Mozambique make use of the remora for fishing purposes. Passing a ring, to which a cord is attached, through the tail of the creature, they send it in pursuit of any passing fish or turtle; and so tenacious is its hold that the object of its attachment is usually secured.

Few fishes are better fitted to succeed in the struggle for existence than the angler or fishing frog, which, hiding itself for the most part in the mud of the sea-bottom, hangs out its fishing-rod, with tempting bait, right over its capacious mouth. In the branchial sac of this fish, as found in the Mediterranean, an eel is said to reside, and to share in the abundant food supply of the lucky angler. Several small fishes have also been found habitually to lodge in the mouth cavity of a Brazilian cat-fish, sharing such food as the latter may succeed in capturing.

The marine enemies of the smaller fish are so numerous, that it is only by retreating to places inaccessible, or at least distasteful, to their foes that they have a chance of survival. A favourite shelter with many small fishes is the umbrella-like disk of

the larger sea-jellies, the stinging properties of which probably cause them to be avoided by the other denizens of the deep. Among the species most commonly found in this position is the cod, which, according to Professor Sars of Christiania, passes one of the early stages of its existence under the friendly shelter of the medusa umbrella. Shortly after emerging from the egg, the young fry of the cod retire to deepish water for a while. When about an inch in length, however, they once more seek the shallow water of the coast, and in making this approach the codlings are said to be guided by the medusæ, beneath whose tentacles they shelter themselves. The partnership is believed in this case to be mutually advantageous, the fry sharing in the minute food which the jelly-fish is able to stupify by its stinging tentacles, while they in turn relieve their host of certain parasites which infest it.

As many as twenty fishes have, according to A. Agassiz, been counted swimming within the fringed margin of one of these pulsating umbrellas. Dr. Collingwood, when sailing in the China seas, once observed a large number of individuals of the sea-jelly popularly known as the "man-of-war," each of which had beneath its bladder, and protected by its long tentacles, a cluster of about a dozen small fishes. He also observed that while every "man-of war" had its shoal, the fishes under small specimens

of this sea-jelly were small, while those under larger ones were correspondingly big.

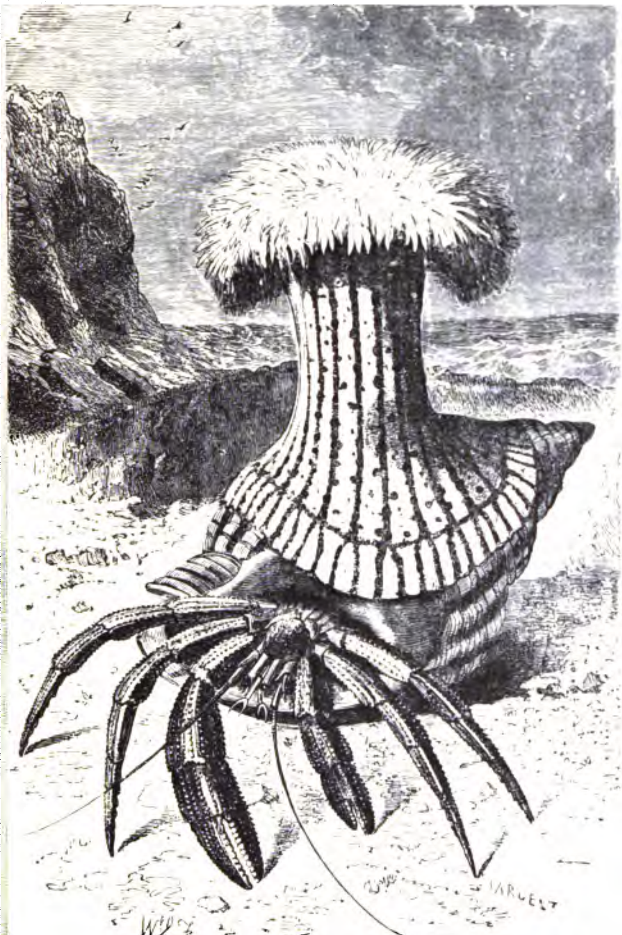
The same naturalist-traveller was among the first to notice the existence of a fish-sheltering sea-anemone. He discovered on a reef in the neighbourhood of Labuan an anemone which when expanded measured fully two feet in diameter. Over this monster zoophyte there hovered a pretty little fish, which when driven off invariably returned to its former position. Suspecting some connection between fish and anemone, he began raking about with a stick in the body of the latter, and succeeded in dislodging six similar fishes from the body cavity of the zoophyte. From the ease with which they allowed themselves to be captured, they were evidently unaccustomed to swimming far beyond the protection of the stinging tentacles of the anemone.

The holothurians, or sea-cucumbers, are another group of lowly marine forms which afford shelter to fishes. The eel-like fishes forming the genus *Fierasfer* have this habit; but they are not the only commensals of those accommodating sea-cucumbers. Professor Carl Semper, when investigating this subject among the Philippine Islands, found shrimps and pea-crabs as well as the *Fierasfer* living within the respiratory cavity, and sharing in the food supply, of a single holothurian. He further states that he has seen specimens which in this

matter bore a considerable resemblance to a hotel with its table d'hote.

A copartnery profitable to both parties exists between several species of crabs and sea-anemones. In the China seas there is a crab which invariably has the same species of anemone on its back, while the latter, it is said, is never seen apart from the crab. By this association the normally sedentary anemone becomes as locomotive as the roving crustacean, while the crab gladly bears the burden for the protection its commensal fortress affords. Further: there is a hermit crab, which tenants a molluscan shell, but which also contrives to have a particular species of anemone always attached to its adopted home. How friendly the two are was shown by Mr. Gosse; for when he removed the anemone he found that the hermit invariably took it up again and held it patiently in its claws against the shell, for about ten minutes at a time, until it had fairly taken hold again.

There are other two species of crabs noticed lately by Professor Möbius, which have the singular habit of taking a sea-anemone in each claw, and of thus carrying them about. With their tentacles expanded, these zoophytes probably serve to screen the crabs from the observation both of their enemies and of their prey; just as certain other crustaceans cultivate a colony of polyps on their backs with the view, or at least with the result, of deceiving the



HERMIT CRAB WITH ANEMONE.

creatures for whom they lie in wait. Other instances might be given, such as that of the little pea-crab found occasionally in mussels and other bivalve shells, which, in return for the protection afforded by the molluscan shell, gives its host a share of the food it captures. These, however, will suffice to show how widely prevalent commensalism is throughout the animal kingdom.

VII.

MIMICRY IN ANIMALS.

LATELY the Duke of Argyll drew attention to a well-marked example of a phenomenon which naturalists have of late years found to be marvellously prevalent throughout the animal kingdom. He observed at Cannes a very handsome moth, which settled on the ground near where he sat, and the lustrous yellow colour of whose wing-margins rendered it at first a conspicuous object. Having taken alarm, however, at some movement in its neighbourhood, the creature gave itself a sudden jerk and instantly became invisible. Looking intently at the place of its disappearance, the Duke saw that the ground was strewn with withered and crumpled leaves, and that one of those leaves occupied the very spot on which the insect had settled. It then flashed upon his mind that this was—as it proved to be—a case of mimicry, the supposed leaf being no other than the brilliant moth of a moment before. So confident was the insect

of the efficiency of its disguise, that it allowed him to approach quite close to it without moving; and he then saw that the golden margins of the fore wings had been folded down out of sight, and that the remainder of the dark-brown wings "were so crumpled up that they imitated exactly the dried and withered leaves around."

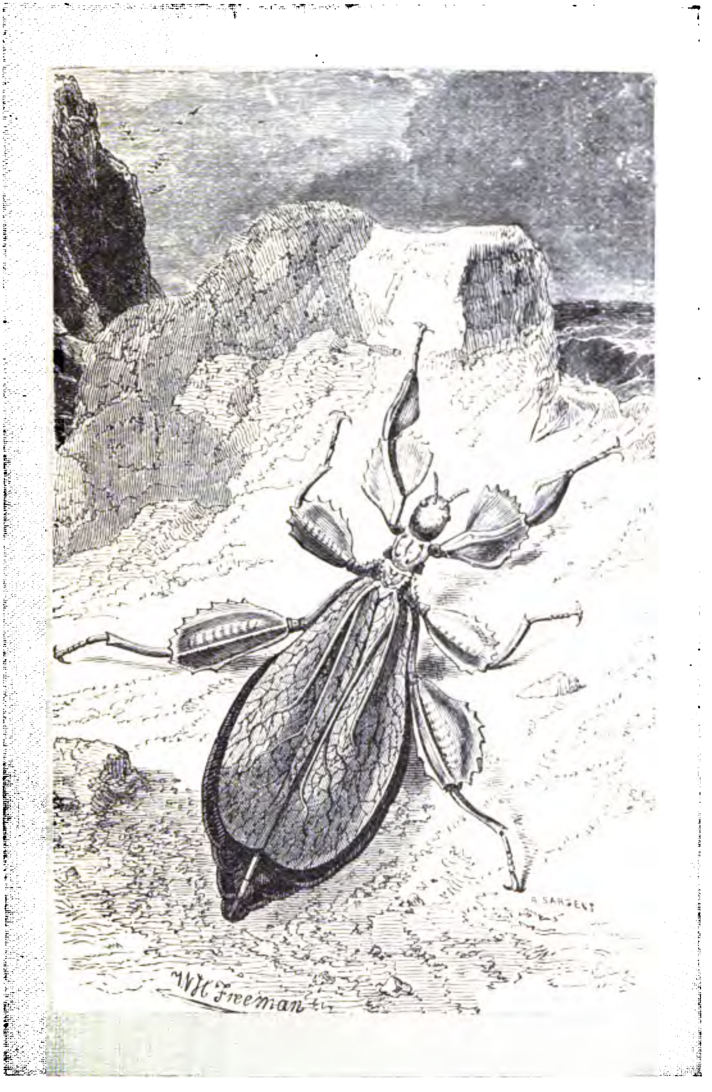
In the above instance the moth exhibited a somewhat minute and detailed resemblance to the dead leaf, while its habits, as shown by its settling among withered leaves, accorded with its deceptive garb. There are numerous cases, however, in which the resemblance of animals to their surroundings is of a much more general character. Thus polar animals, as the bear and the Arctic hare, are white; desert animals, like the lion, are sandy-coloured; while green is a prevalent colour among the birds and other arboreal inhabitants of tropical forests. The mountain hare and the ptarmigan of our own country are white in winter, while their summer coat is of a darker hue. In all such cases, conformity in colour to surrounding nature may safely be regarded as protective, enabling its possessors the better to avoid their enemies or to steal upon their prey.

While instances of this general resemblance in tint between animals and their environment are to be found everywhere throughout the animal kingdom, cases of special adaptation, such as that observed

by the Duke of Argyll, are of most frequent occurrence among insects. Thus A. R. Wallace, in his "Malay Archipelago," tells of a butterfly conspicuous on the wing, but which had only to alight on a twig in order to become indistinguishable from the surrounding leaves. Its wings, placed back to back, concealed the head and antennæ, and resembled a shrivelled leaf not only in shape but in general markings, while the little tails of the hind wings, touching the twig, formed a perfect stalk.

The "walking-leaf" and "walking-stick" insects are further examples of minute imitation, the former, when resting on the foliage which forms their food, being quite indistinguishable to ordinary observation from the surrounding leaves, while the latter are very perfect imitations of dead sticks. No better proof of the effectiveness of the disguise in the "walking-leaf" could be found than that related by Belt in his "Naturalist in Nicaragua," where he states that an army of foraging ants, in search of insect prey, actually passed over the body of one of those creatures without perceiving that they were treading on their favourite food.

In this case, as in all such cases, the insect by its behaviour bore out the deception due to its appearance. With its legs stretched out unsymmetrically, so as to resemble twigs, it remained immovable while the army of ants passed over it; and so convinced, apparently, was it that its safety lay in its



WALKING-LEAF INSECT.

immobility that it allowed Mr. Belt to lift it and to lay it down again without once moving.

The minuteness with which resemblance to vegetable substances is often carried out is seen in the case noticed by Wallace of a "walking-stick" insect brought to him by a Dyak, who said that it was grown over with moss; and it was only after a minute examination that the naturalist convinced himself that the so-called moss was merely an animal counterfeit of it.

Inorganic and vegetable substances are not, however, the only objects imitated by animals for the purpose of disguise. For the same end one animal imitates another; and it was to this phenomenon that Mr. Bates (who first explained the facts) gave the term "mimicry." It is not implied by this term that the imitation is in any sense voluntary; but simply that the mimicking species bears so close an external resemblance to the form mimicked, that, although wholly unlike in internal structure, the one is apt to be mistaken for the other. It is a resemblance that deceives, as will more clearly appear by an example taken from insect life in South America.

There exists on that continent a group of butterflies—the *Heliconidæ*—rich in species and abundant in individuals. They are gaily-coloured insects, that fly about everywhere in the sunshine in the most leisurely fashion. Conspicuous on the wing,

they are equally conspicuous when at rest, and might therefore be expected to fall a ready prey to the insectivorous birds which abound in that region. The fact that they do not, as their marked abundance shows, suggested to naturalists the probability that they possessed some special means of protection. Experiment proved that the juices of their bodies had a strongly pungent odour; and as birds have been repeatedly found to reject such nauseous morsels, there is doubtless sufficient cause in their offensive taste and odour to explain the immunity from attack enjoyed by the *Heliconidæ.*

It would plainly be to the advantage of those unfortunate insects, the sweetness of whose juices recommends them to insect-eating birds, could such an alteration be effected in their external aspect as would make them sufficiently like heliconias to deceive their ornithic enemies. And Mr. Bates found that such mimicry did occur in the case of many edible species of butterflies and moths throughout Brazil. He observed that several species of a family of butterflies—*Leptalides*—allied to our common cabbage form, and therefore very unlike heliconias, had discarded their family livery, and adopted that of the more favoured group.

In these cases the imitation is for the most part very perfect, every bar and spot of colour in the model being reproduced in the mimicking species. So completely is the eye deceived, that both Messrs.

Bates and Wallace frequently took specimens which they supposed to be heliconias, but which on closer examination proved to be mimicking leptalides. Mixing, as those insects do, with the heliconias, and imitating their lazy flight, they no doubt deceive the insect-eating birds, as they did the naturalists, and share in the immunity from attack enjoyed by their models.

They are not the only forms which seek safety under a similar disguise,—a genus belonging to another family of butterflies, and no less than three genera of day-flying moths, having been found to imitate the nauseous heliconias.

Mr. Bates also found that certain species, belonging to different groups of *Heliconidæ*, mimicked each other; and as here both the imitated and imitating species were protected by their distastefulness, it was not clear how the one could be benefited by resembling the other. Recently, however, Fritz Müller has shown how this may be advantageous. His theory proceeds on the assumption that young insectivorous birds only learn by experience that the various species of heliconias are distasteful, and that in learning this lesson they sacrifice a considerable number of individuals of each species of those insects. Suppose the insectivorous bird has to kill a hundred of each of two kinds of heliconias before discovering that both are uneatable, it is evident that if one of those species should come to

resemble the other so that the bird could no longer distinguish between them, the number of victims would be divided between the two species to the advantage of both. As the mimicked species, however, almost always occurs in immensely greater numbers than its mimic, the loss falls almost wholly on the former. It may thus be decidedly advantageous for one species to resemble another which is more abundant in individuals, although both possess distasteful qualities.

The South American butterflies are not the only insects mimicked. There are other groups, both in the Old and New Worlds, which have, like them, special means of defence, and which are accordingly more or less closely imitated by otherwise defenceless species. Bees and wasps, as might be expected from their possession of stings, are among the insects most frequently mimicked. In Britain, for example, they are imitated by the clear-wing moths, one of which resembles the common humble-bee, and another the hornet; while in America there is a long-horned beetle which so closely mimics a particular kind of wasp, found in the same neighbourhood, that Mr. Bates was afraid to take it out of his net with his fingers for fear of being stung.

Instances of mimicry among insects might be multiplied almost indefinitely; they are not unknown, however, in the higher groups of animals, there being well-marked cases of harmless snakes

mimicking poisonous forms, and of weakly birds, like the cuckoo, imitating birds of prey.

The more striking cases of mimicry were observed shortly after the publication of Mr. Darwin's famous theory, and they are interesting as being among the first groups of new facts which the doctrine of natural selection was called upon to account for. It is needless to show at the present day how susceptible of explanation the phenomena of mimicry and protective resemblances proved in the light of Darwin's comprehensive theory.

Those who still maintain that these facts were sufficiently explained before Darwin was born, by the doctrine of special creation, according to which, for example, the lion is of a uniformly tawny colour simply because it was created so, have a hard nut to crack in the fact that the young lions while they lie protected in their mother's womb are profusely spotted and striped; and that even after birth, while as yet they have not to seek their food, they show more or less of those markings. Why this homage to the family livery if indeed the doctrine of descent be a delusion and the survival of the fittest a snare?

VIII.

ANIMAL INTELLIGENCE.

In view of what it has achieved, the human intellect is a thing for its possessors to be reasonably proud of; and it is difficult to see how this cause of legitimate satisfaction need be at all lessened should it be proved that the intellect of brutes is the same in kind, however different in degree from that of man.

It is generally conceded that the higher animals are for the most part subject to the same emotions as ourselves, and there are many who would even concede to their favourite dog the possession of the rudiments of a moral nature, and of a religion in which man would figure as its god, and his will as its rule of conduct.

Animals are known to go mad, and a recent French writer, M. Houzeau, gives an instance which came under his own observation of what is not so well known—namely, of animal idiotcy. The case referred to was that of a dog, which was utterly unable to take care of itself or to provide food for

its own wants. Its mother, however, had intellect enough to perceive her puppy's mental incapacity, and from the time it ceased to suckle she took pains to provide it with food—a thing she had never before done to any of her offspring.

Many people, however, will not allow that animals are ever guided in their actions by the faintest glimmer of reason,—instinct, an expression which, according to Professor Haeckel, has given rise to more errors and misunderstandings than any other, is supposed to explain all,—and if certain of the domesticated animals seem occasionally to be thus directed, it is attributed to the power they have acquired, through long intercourse with reasonable beings, of mimicking their methods.

This question, like all others of a biological kind, has gained largely in interest and purpose from the wide acceptance which the doctrine of evolution has latterly obtained, and no better proof of this could be found than in the very interesting discussion on "Intellect in Brutes" which lately appeared in the pages of *Nature.* During its course a large number of hitherto unrecorded instances of supposed reasoning in animals has come to light, and these have been subjected to a criticism which in only a few cases can be said to have proved wholly destructive.

This fate, however, undoubtedly befell the instance the publication of which led to the discussion. On

ring the bell while the maid was in the room. It looked first at its mistress, then at the maid, but took no notice whatever of the order, although it was given more than once. On the girl leaving the room the order was repeated and at once obeyed.

This does not, however, satisfy Mr. Henslow, who thinks that had the dog possessed *abstract* reasoning it would, on seeing the girl in the room, have supposed that it had been told to ring the bell for some one else. What Mr. Henslow desiderates would seem, however, to have been supplied in the case of a cat, thirteen years old, which, although never taught to knock at the door, is, and has been for three years past, in the regular habit of making use of a knocker just within his reach, as he stands on his hind legs, in order to gain admission. He begins with a single knock, which, if not attended to, is followed by the well-known "postman's knock," and if this should prove unsuccessful, "trial is then made of a scientific rat-tat that would not disgrace a West End footman." The same cat has still further shown his appreciation of human ways by developing a fondness for brandy and water.

The elephant generally figures in discussions of this sort, and in the present instance a single example of its reasoning powers was sent all the way from New York. In the Central Park of that city an elephant was observed, during a very hot day, taking up great trunkfuls of new-mown hay and

spreading them over its back until that part had become completely thatched. It then stood motionless, enjoying the coolness its own ingenuity had produced. Instinct would have prompted it to eat the grass; the utilizing it for the purpose of screening itself from the sun's rays looks altogether like a *reasonable* act.

To find the donkey among the number of reasoning animals is probably more surprising. The appearance, however, which it makes in the columns of *Nature* is highly creditable to it. A donkey which, when not employed by its master's children, used to graze in a field with some cows, was in the habit, when milking-time arrived, of lifting the latch of the field gate and holding it back until all the cows had passed out, when it allowed the gate to swing close again, and went home with them. This bit of gallantry and intellect it owed entirely to nature's teaching.

As might have been expected from the greater opportunity man has of observing them, from the training which their faculties undergo, and their exemption from that struggle for a mere subsistence which is supposed to hinder the development even of man's intellectual powers, the domesticated animals afford most of the examples of animal reasoning. Many of the fur-bearing animals of North America, however, have long been known for their *'cuteness* in circumventing the trapper, and Dr. Rae

testifies to this in the case of the Arctic foxes. Wishing to capture some of these, he tried various traps, but as they were all familiar to the foxes they were of no use. He accordingly tried a form of trap new to that part of the country, consisting of a loaded gun, fixed on a stand, and pointing to the bait, which was connected with the trigger by a string thirty yards in length, and for most of its length concealed under the snow. The bait, on being seized, caused the gun to go off, and the fox thus committed involuntary suicide. By this new stratagem Dr. Rae secured one fox, but no more. The survivors set themselves to unravel the mystery, and that they succeeded was soon shown by the methods they adopted to secure the bait without losing their lives. They either cut the string connecting the bait with the trigger, or, burrowing up to it beneath the snow at right angles to the string, they pulled it down beneath the line of fire.

These are only a few examples of the many which have lately been made public, and they will probably suffice to show that, however great may be the difference between the animal mind and that of man, animals are at least not destitute of reasoning power. The ultimate source of this difference is believed by many to lie in the possession by man of the faculty of speech, by which he can deal with abstract ideas too complex to be capable of development without the aid of language. If this be so,

the question whether human intelligence differs from that of brutes in kind, or merely in degree, "hinges entirely," as Mr. Romanes expressed it lately before the British Association, "on the question whether the faculty of speech has been of an origin natural or supernatural."

IX.

THE WAYS OF THE ANT.

It is only in the matter of bodily form that the higher apes can be said to make the nearest approach of all animals to man. In other respects their ways are emphatically not our ways; while the nearest approximation to ourselves on other points is to be found, not in any one of the backboned animals, but among the social insects, and more particularly in the ant, the communities of which present the most striking analogies to those of man.

All animals stand more or less in awe of man. Not less, however, do they seem to fear this tiny lord of the insect world. When the armies of the "foraging ants" pass through a tropical forest there is a regular stampede of scorpions, centipedes, and venomous spiders; while in Central Africa the ap-
h of the "driver ants" is said to be sufficient
such big game as elephants, lions, and
s to flight. Even man himself has some-

times to make way for its organized hosts. Bates tells of a town on the banks of the Amazon which had for a time to be abandoned, the fire ants having made it too hot for its human inhabitants. When this traveller visited it the people had just returned, and he found that it was only by having the legs of tables, chairs, and stools smeared with copaiba balsam, and by having provisions and hammocks suspended by cords dipped in this—to the ant—non-conducting substance, that it was possible to protect person or property from their furious attacks. Where vegetarian ants abound, their influence on the surrounding plant life is equally marked. No axe-wielding arm could doom a tree more certainly than do the scissor-like jaws of the leaf-cutting or "parasol" ants.

Certain species, as has been recently pointed out by that most indefatigable student both of men and of ants, Sir John Lubbock, resemble the lower races of mankind in living chiefly on the products of the chase; others have reached the pastoral stage, having succeeded in domesticating such creatures as the *Aphides*, commonly known as "Ants' Milch Cows," from which by means of their antennæ they extract a sweet liquid in much the same way as milk is obtained from the cow. Professor Leidy of Philadelphia recently observed no fewer than three different kinds of domesticated insects belonging to a single community of ants, all of which were kept

in separate herds and evidently tended with the greatest care. It was also lately stated that in Canada they have succeeded in domesticating the caterpillar of a butterfly, doubtless for the sake of a clear saccharine fluid which exudes from a teat-like organ on its back. Although of no service to them during winter, the ants have been observed to keep their dairy stock alive all the year round.

Others again, such as the harvesting ants, may be said to have reached the agricultural stage. One of these, the agricultural ant of Texas, which has been specially studied by Dr. Lyncecum, is said to clear a plot of ground four or five feet in width around its city, removing all existing vegetation, and sowing it with a peculiar grass, during the growth of which the ants guard their farm from the attacks of other insects, and keep it free from weeds. When the seeds are ripe, the crop is reaped and the grain conveyed, after due winnowing, into their granaries. These agricultural ants have also certain funeral regulations—the dead bodies of comrades receiving decent sepulture and other tokens of respect denied to the corpses of aliens. Their intelligence, too, is shown by their quick avoidance of poisoned food.

Among other species, slavery is a recognized institution, and the ants appear to work that system much more satisfactorily than seems ever to have been done by man, as the slaves, which are all kid-

napped while very young, seem quite contented with their lot, and in most cases fight eagerly for their masters, although Sir John Lubbock mentions a case in which, from the absence of either affection or hatred in certain slaves, he was almost tempted to surmise that their warlike spirit had been broken by slavery. To such an extent, however, has this institution been developed that at least one species is known — the Amazon ant — which is totally dependent for its existence on the services of its slaves. It can neither make its own nest nor feed its own young, and it would rather starve than feed itself. Its members form simply a military aristocracy, whose sole occupation consists in the acquisition of slaves by war. Sir J. Lubbock succeeded in keeping some Amazonian ants alive for several months by allowing them a slave for an hour a day to feed and clean them. On the latter point all ants are scrupulously particular,—the agricultural species, even in confinement, frequently and thoroughly cleansing themselves, especially after eating and sleeping. They also assist each other at their toilets, and are said to evince the liveliest satisfaction during the operation.

Communism, which has always signally failed when attempted among human societies, is an accomplished fact among ants. There is no such thing as private property in the formicary; and that the system of having all things in common works

admirably is seen in the untiring industry of those creatures, and in the perfect harmony which reigns in the ant-hill. Ants of the same nest, according to Sir J. Lubbock, never quarrel; nor had he ever seen any evidence of ill-temper towards each other. The secret of their success in this, humanly-speaking, Utopian scheme lies in the absence of the family tie, due to the fact that the influential element in every ant community—the workers and fighters—are neuters, who neither marry nor are given in marriage, and who consequently have no attachments save those which bind them to the community. Like nations, also, ant communities have their times of growth followed by an apparently inevitable period of decay, and thus every ant-hill might, as a recent writer puts it, have its Gibbon.

Prominent among ant investigators is Dr. M'Cook of Philadelphia, who has recently given an account of his researches on a novel phase of ant-life, as exhibited in the honey-bearing ant. Its mode of storing honey for winter use has hitherto been regarded as the one feature in which the bee excelled the ant. The discovery of those honey-bearers in New Mexico, however, shows that the ants have hit upon a method of storing honey even more remarkable than that exemplified in the formation of wax cells—namely, by transforming certain of their fellows into living honey-pots. Dr. M'Cook discovered those insects in Colorado, and

SECTION OF AN ANT-HILL.

there studied their habits. Suspended from the roof of their subterranean chambers he found those living honeycombs—strange-looking creatures, with abdomen distended to the size of a marrow pea, while head and breast together were not much bigger than a pin's head. Towards evening the workers were seen to leave the nest and make their way to a species of oak tree, the galls of which, unlike galls in general, exude a sweet liquid. Gorged with this, the ants returned to the nest and ejected their nectar from their own mouths into those of the suspended honey-bearers. When hungry ants wish to draw upon their store, a slight contraction of the abdomen causes the honey to exude from the mouth of the honey-bearer, when it is eagerly lapped by the workers. The digestive organs of those creatures are so driven into a corner and aborted, that Dr. M'Cook inclines to the opinion that the digestive function must be in abeyance; but as the "honey-pots" live and exert themselves to the extent of expelling their nectar when required, a certain amount of food assimilation would seem to be imperative. In New Mexico those honey ants are used by the inhabitants as an after-dinner dessert. A plateful being placed on the table, they pick them up singly, nipping the honey-bag with the teeth and forcing its contents into the mouth.

The most extensive observations that have yet been made in this country on ants are undoubtedly

those of Sir John Lubbock, who has kept no fewer than thirty-five species of ants in confinement, whose ways have been made the subject of daily and at times of hourly observation by himself and family. Many of the results of his observations and experiments on those creatures are equally curious and unexpected. It seems almost impossible that in an ant-hill, which often contains a population of over one hundred thousand individuals, each of these should be able to distinguish the members of their own community from (to our senses) the exactly similar individuals of a neighbouring nest of the same species. It would appear, however, from those experiments, that not only can they at once tell a friend from a stranger, but that they can do this although the friend may have been absent from their midst for more than a year. When strangers and long-absent friends were thus introduced into a nest, the latter were amicably if not effusively received, while the former were at once attacked. How this recognition is effected has not yet been satisfactorily made out, although the theory that it was by means of a password or sign peculiar to each community is shown by those experiments to be untenable.

Much has been said regarding the helpfulness of ants towards each other when in distress, and their mutual affection; and while not calling in question the correctness of previous observations on this

point, Sir John shows that the results of his investigations hardly bear out the prevalent opinion. He tested their benevolent sentiments by placing friends in positions requiring assistance for their extrication, but the ants, in the great majority of cases, took no notice whatever of their distressed comrades; only a very few showed some fellow-feeling, and on the strength of those cases he concludes that "there may be priests and Levites and good Samaritans among them as among men." In one instance, where a poor ant which had been born without antennæ—a misfortune among ants not less serious than that of being born blind among men—had strayed from its nest, and had fallen among ants of a different species, who left it for dead, an ant of the good Samaritan stamp passing that way stopped, examined the helpless creature, and picking it up tenderly carried it off to the nest.

Whatever may be the strength of their affection, he shows that it is altogether outbalanced by the intensity of their hatred towards enemies. To test this, two ants were taken and placed in a bottle the open end of which was covered by a layer of thin muslin, and in another bottle similarly closed two ants of the same species, but taken from a different nest, were placed, while both bottles were laid close to the nest. The ants in the nest were then watched to see if they would in any way succour the two ants belonging to their own community,

either by carrying food or by attempting to rescue them. They did neither—in fact, they took no notice whatever of them, but devoted their entire attention to the two strangers, for whose lives they evidently thirsted; and after several days of constant watching and working, they at length succeeded in cutting the muslin, and having thus effected an entrance, they immediately attacked the strangers.

In order to test both their affection and their intelligence, he put several ants of a particular nest, with an equal number of stranger ants, under chloroform, while others he intoxicated. The insensibility produced by chloroform was evidently regarded by the ants as death, and they treated the bodies of both friends and strangers alike, dropping them into the water surrounding their nest. The intoxicated ants were a great puzzle to their friends; as a rule, however, they had the discrimination to convey their drunken comrades into the nest, while they drowned the inebriate strangers.

It is a well-known fact that, when an ant comes upon a store of food, it is soon joined by others of the same community. Some have supposed that the latter reach the store simply by following the ant after seeing it going and returning laden with food; others that it had some means of informing its friends of such an occurrence, and of directing them to the spot. With the view of throwing light on this point, Sir John determined to see what would

be the result of "compelling the ant who found the treasure to return empty-handed." If in this case she returned bringing an auxiliary force, it would prove that some communication must have passed. He accordingly fixed down with a pin a dead blue-bottle which an ant had begun to drag homewards, when, finding all her efforts to move it unavailing, she returned to the nest empty-handed. In about a minute, however, she emerged with seven others, whom she led to the prize. In another experiment of a similar kind, the ant succeeded in inducing twelve others thus to come to her assistance.

These experiments put it beyond doubt that ants have a language of some sort by which they can make themselves intelligible to their neighbours. Do they communicate by sounds audible to themselves though inaudible to us? In investigating this point Sir John placed a telephone over an ants' nest, and then disturbing its inmates, he held the other end of the telephone over a neighbouring ant community. If the disturbed ants made any noise, he expected in this way to convey the sound to the other nest, where a similar disturbance would be produced. This, however, it failed to do; but the failure might be due not so much to the total absence of sound as to the want of a plate sufficiently delicate to be set in vibration by such "microscopic" sounds.

The means by which ants hold communication

with each other is thus still in dispute, although the prevalent view is that they talk by means of their antennæ. Sir John found also that ants have weak vision, strong scent, and, so far as he could discover, no hearing. He has also proved that they possess the power of distinguishing colours, being specially sensitive to violet.

The works of Bates, Bell, and other naturalist travellers have made us familiar with such remarkable instances of ant-intelligence as have seemed to many people to break down all distinction between instinct and reason. Sir J. Lubbock's experiments to test the intelligence of his domesticated ants would seem to show that, so far as the individuals he operated on are concerned, their fertility of resource has been somewhat overrated. Thus after traversing for hours a particular route, engrossed in the congenial occupation of carrying larvæ to their nests, the interposition of the slightest obstacle, which the exercise of a tithe of the ingenuity they have been usually credited with could have overcome, was found effectually to bar their progress.

Too much stress need not be, and is not put by Sir J. Lubbock, upon these experiments in coming to a conclusion on the intelligence of the entire group of ants; and when viewed in the light of the following equally well authenticated case, given by Kerner in his recent work on "Flowers and their Unbidden Guests," would seem only to show that

ants, like men, are not always equally wise. One of Professor Gredler's colleagues at Botzen was in the habit of sprinkling pounded sugar on the sill of his window for a train of ants which passed in constant succession from the garden to the window. One day he put the sugar into a vessel and suspended it by a string to the transom of the window, putting a few of the ants into it, that they might afterwards communicate to their friends the knowledge of the sugar supply overhead. Those ants soon found their way down by means of the string, and shortly afterwards the old stream of ants was to be seen passing to and from the sugar vessel. After a day or two, however, the traffic suddenly ceased, and the ants were observed occupying their old ground on the window-sill. This was not, says Kerner, because the store above had been exhausted, but because some dozen little fellows were working away vigorously and incessantly up aloft in the vessel, dragging the sugar crumbs to its edge and throwing them down to their comrades below on the sill—a sill which, with their limited range of vision, they could not possibly see.

X.

THE MIGRATION OF BIRDS.

It was formerly supposed that those birds which disappear on the approach of winter merely retired into caves and other dark places of the earth, where they lay dormant until the warmth of spring roused them and their insect prey into new activity. They are now known to migrate. Many of them, as the swallow, make no secret of it; they may be seen for days collecting by thousands on or near the coast, and in hosts they take their departure. Others—and these form the majority of "birds of passage"—seem to slip away singly and unobserved.

The number of birds which feel the migratory impulse is much greater than is generally supposed, many species which are resident all the year round in one place being migratory in another. Thus those model home-loving birds in this country, the chaffinch and the hedge-sparrow, are migratory in certain districts of the Continent; others, as the redbreast and the song-thrush, which only close observa-

tion has shown to be migratory, and that to a very limited extent in this country, are notoriously so on the Continent. These and other similar facts have led Professor Newton to conclude that probably every bird belonging to the northern hemisphere is, to a greater or less degree, migratory in one part or other of its range.

Why, it may be asked, do birds thus migrate? The most obvious cause is undoubtedly to be found in their desire to obtain a sufficiency of food. The birds of the far North—the snow-buntings, the turnstones, and a host of ducks and waders—come to us in winter to obtain the food denied them for a season in the frozen Arctic; while others, as the swallow and the swift, leave us then to seek in more Southern climes the insect food which our winter cold destroys.

The migratory birds thus move in autumn from north to south to avoid starvation. In spring they return, probably, though not so evidently, for the same reason, to their former haunts. They are still further attracted northward by the affection with which most of them cling to their old breeding-grounds. Thus falcons are known to have bred on the same spot for over a hundred years, and such migrants as the stone-curlew will continue to return to and build on the same ground after its character has been altogether changed by cultivation or otherwise.

The migratory "instinct" has thus probably arisen out of the habit, which all wild animals have to a greater or less degree, of wandering in search of food, greatly exaggerated, however, in the case of birds, as Mr. A. R. Wallace remarks, "by their powers of flight, and by the necessity for procuring a large amount of soft insect food for their unfledged young." The regularly recurring dearth of such food would produce a periodicity in the wandering habit; and as the latter would be inherited, it may be supposed that, aided by natural selection, the migratory impulse grew stronger with every succeeding generation. The strength of this "instinct" as now developed is seen in the excitement of caged birds when the time arrives for the migration of their free companions, and in the fact that they have been known to abandon their still helpless young in order to obey it.

As to the destination of our migratory birds, it is well known that most of the spring and summer visitors to Britain and the north of Europe pass the winter in North Africa and Western Asia, while our winter visitors retire to the extreme north of Europe and Asia. How they reach those quarters forms one of the greatest puzzles in the entire field of natural history. That in doing so they accomplish enormous journeys is well known. The Swedish bluethroat, which breeds in the northern parts of Scandinavia, suddenly transports itself to the valleys of the Upper Nile, where it winters, and from which

it returns unerringly in spring to its former breeding quarters. The stork leaves the marshes of Holland, and a few days later is seen still flying southward in immense flocks over Eastern Soudan, probably having its winter quarters among the lakes of Central Africa.

Seas such as the English Channel and the Mediterranean form no barrier to those movements. It is a well-known fact, however, that in crossing the Mediterranean they select one of three routes—by the south of Spain near Gibraltar, by Sicily over Malta, or by Greece and Cyprus. These might have been chosen as affording the shortest sea-passage to Africa; but there is now little doubt that they were selected as migration routes at a time when continuous land existed at those places. There is abundant geological evidence to show that at a comparatively recent period the Mediterranean formed two lakes,—the result of land connections between Europe and Africa by way of Spain and Italy. At the same time England was joined to the Continent; so that those birds which now-a-days astonish us by crossing two seas on their migratory tour, probably acquired the habit at a time when no such maritime difficulties intervened. They travelled by those land-bridges; and so slowly did the land slip from under their feet and disappear beneath the waves, that no single generation of birds can have been aware of any change.

That the route, however, is by no means so safe as it once was may be inferred from the fact that large numbers of birds get drowned in making the passage during rough weather. This is specially the case with the great flocks of quails which thus migrate to North Africa, and many of these birds now go no further than the northern shores of the Mediterranean. Were the sea to become still wider, it is not improbable that the migration of the quail to Africa would altogether cease.

Migratory birds frequently travel by night, although in crossing the Mediterranean they are said to choose moonlight. Dark, cloudy nights would seem also to disconcert them in their journeying,—Professor Newton and others having noticed that on such nights the cries may frequently be heard of a mixed multitude of birds hovering over towns as if at a loss to know whither to proceed, and apparently attracted by the lights of the houses.

Marvellous as it is that those birds should be able to direct themselves to a given point—a former breeding or feeding place—hundreds, or it may be a thousand miles away, it is no less wonderful that they should so time their starting as to reach their destination at almost the same date every year. "Occasionally," says Professor Newton, "the return of the swallow or the nightingale may be somewhat delayed; but most sea-fowls may be trusted, it is said, as the almanac itself. Were they satellites

revolving around the earth, their arrival could hardly be more surely calculated by an astronomer. Foul weather or fair, heat or cold, the puffins repair to some of their stations punctually on a given day, as if their movements were regulated by clockwork."

Many theories have been started to explain how migratory birds steer their course between their summer and winter resorts, but none of these can be regarded as altogether satisfactory. To say, as some do, that it is due to instinct, or to the possession of a sixth sense, is simply to confess our inability to solve the problem. A German naturalist —Herr Palmen—has propounded a theory which, without invoking unknown forces, makes the nearest approach to an explanation of the known facts. He maintains that birds learn to find their way by experience, partly individual and partly inherited. Migratory birds do not fly straight to their goal, as they might be expected to do had they a sixth sense to direct them. They follow, and may therefore be supposed to be guided in their course by, the physical features of the country spread out beneath them. Here it is the windings of a river, there of a valley or a sea-coast, that are followed; but so far as Herr Palmen can discover, there is no deviation from those established routes. The young bird comes into the world with a highly-developed geographical faculty, which enables it, as it follows the old birds in its first migration, to make inward note of the route,

and to turn its individual experience to profitable account in future journeys.

That those birds inherit a sharp eye and a retentive memory for locality is only what might be expected, and much of the migration which takes place over continuous land surfaces, as in North America, might be thus accounted for, could it be shown that the young birds in migrating usually accompany their elders. This, however, would seem to be far from the case. The young and the old are said, on the authority of Temminck, always to journey apart, while in many cases the young start first on the southward journey. The most conclusive evidence on this point was that lately contributed by Mr. Gätke, the well-known observer of bird life on Heligoland, who stated that of the three hundred and sixty species of migratory birds which he had himself taken on that island, in one case only did the old birds precede the young in the autumnal migration. In all others the young birds in their first migratory trip got the start of their parents by some weeks, the old males being, strange to say, the last to migrate. The cuckoo formed the sole exception, the old birds in this case migrating at least a month earlier than their young. No better example, indeed, of the young birds' entire independence of parental aid with regard to migration could be found than that of the cuckoo, which leaves its eggs to be hatched by other birds, and whose young,

therefore, never see the adult form of their species until they have successfully performed their first migration.

In spring, however, the birds return in reverse order, the most perfect old males, according to Gätke, appearing first, followed soon by old females, and later by the young birds,—"the rear," says this accurate observer, "being brought up by the halt and lame—crippled birds that have lost a greater or less number of their wing or tail feathers, some toes, or even a whole foot."

It is difficult to understand how inheritance of anything short of actual geographical knowledge could enable the cuckoo to follow its unknown parents to their African haunts. It is almost as difficult to understand, on Palmen's theory, how birds succeed in crossing wide arms of the sea, where landmarks must fail them. It is probable that in crossing the Mediterranean, owing to the height at which they fly, and the islands that lie in their way, they never lose sight of the land; but the same can scarcely be said of two species of New Zealand cuckoos, one of which is a visitor from Australia, with hundreds of miles of the open sea intervening, and the other from equally distant Polynesian islands.

The whole truth as to how birds migrate is, therefore, plainly not yet attained; and although few subjects have so long engaged the attention of observers,

further observation is still necessary. Messrs. Harvey-Brown and Cordeaux have lately hit upon a plan for obtaining trustworthy information on this subject, which promises to be fruitful in results. They have succeeded in enlisting the services of a considerable proportion of the keepers of lighthouses around the British coast, than whom no class of men have better opportunities or more leisure for such work. The returns already obtained from this source have been digested by the above-mentioned ornithologists, and the results are now appearing in a series of annual reports on the migration of birds. It is to be hoped that this happy idea will continue to be productive of such annual reports, from which, in the course of a few years, such *data* may be obtained as will help to unravel this "mystery of mysteries" in bird life.

XI.

EMIGRANT PLANTS AND ANIMALS.

THE profound influence which civilized man has exercised over the distribution of plants and animals finds its most striking illustration on the American continent. The first settlers naturally brought with them their domesticated animals, stray individuals of which escaping, returned to their primitive wildness, and in course of time stocked the New World with wild races of horses, cattle, and hogs.

Those early emigrants, however, brought from the old country, as stowaways on board their ships, many animals which they would willingly have left behind. The British black rat thus effected a landing, and with plenty of food, few enemies, and an astonishing power of multiplication, it took possession of the land even more quickly than did the white man.

Meanwhile the brown or Norway rat had introduced itself into Britain, and soon all but exterminated the weaker indigenous species. Emigrating

to America, this victorious rodent renewed the conflict with its old antagonist; and it has since been steadily marching westward, driving the black rat everywhere before it, and occupying the land in its stead. In this way, says Professor Claypole, in a recent paper on this subject, "state after state has been overrun, so that it is impossible to doubt that ere long the whole sub-domain of Canada and the States will be as thoroughly held by those vermin as are the subterranean portions of human dwellings in the Old World." Mice have been equally successful emigrants, and nowhere throughout the above-named region is the colonist without this mischievous reminder of the mother country. An emigrant of a different sort is the sparrow, now as familiar in American towns as at home, and generally regarded as a benefactor owing to the enormous quantity of insect grubs it devours.

The animal emigrants from Europe to America have, however, been chiefly insects, the majority of them unfortunately coming under the category of "insect plagues." The common house-fly is now as ubiquitous there as here, and even more annoying; as also are the blue-bottle and flesh flies. The cockroach is rapidly spreading from east to west of the continent, everywhere ousting the native species. There is hardly a fruit-tree or a vegetable introduced from Europe that is not now attacked by the insects which formerly preyed upon it. The codling

moth and the apple-tree-bark louse, both European introductions, work havoc among American apples to an extent altogether unknown in Old World orchards. The European onion fly has spread over all the Eastern States, doing infinitely more damage than the indigenous species. For more than two hundred years the cabbage was allowed to grow in peace in America; but in 1857 the cabbage-butterfly of this country was introduced, and is now found almost everywhere to the east of the Rocky Mountains. Like most other introduced insects, it does incomparably more damage in the land of its adoption than in Europe, eating into the very heart of the cabbage. Its depredations in New York State alone for a single year are said to have amounted to five hundred thousand dollars.

A whole army of grain-eating insects has been introduced, including the grain-weevil and the meal-worm; but of these incomparably the most destructive are the Hessian fly and the wheat-midge—the former supposed to have been introduced during the War of Independence by some Hessian troops in the straw imported for their horses. It is, however, less injurious than the wheat-midge, which is believed to have entered America by Quebec about fifty years ago. "In consequence of the presence of this insect," says Dr. Fitch, "over all the New England States, and all New York and Canada, except their western parts, wheat has wholly ceased

to be a staple product." To the noxious immigrants may be added the clothes, fur, and carpet moths, and many others.

Of innocuous immigrants there are a few, such as the rare British butterfly, the Camberwell Beauty; while in the honey-bee, introduced from Europe, there is almost the only example of a useful insect importation.

America, with its exuberance of honey-yielding flowers, has, strange to say, no indigenous honey-bee. Now, however, the European species, known to the Indians as the "English fly," occurs wild from the Atlantic to the Pacific; while bee-keeping has become an important national industry—the annual honey harvest of the States amounting to fifteen million pounds.

America, on the other hand, has contributed but little to the European insect fauna. None of the native pests that prey-upon the fruit-trees of America have obtained a footing in Europe. A small American ant, a meal-worm, and the pea-weevil are, with one exception, the most important. That exception is the gall-louse, *Phylloxera vastatrix*, which, after being known for a dozen years in America as parasitic on the vine, found its way to France about the year 1865, and has since done incalculable injury to the vine crops of that and other wine-producing countries of Europe. In America its attacks are as yet confined to certain

varieties of the vine, and the replanting of the vineyards of France with such varieties as yet enjoy immunity has been advocated, and to a limited extent, we believe, adopted.

The migration of insects from America to Europe naturally suggests the potato-beetle. This insect has travelled right across the American continent, maintaining and propagating itself on the potato plant, until at length it has reached the Atlantic seaboard. Will it, in spite of official vigilance, obtain a footing in Europe? The chances seem to be altogether against it. It runs the risk of detection on embarking, and still greater risk in disembarking, while probably the chief safeguard against its introduction lies in the widespread knowledge throughout Europe of the dreaded creature's appearance. Amply forewarned, the potato cultivator is in this respect fairly forearmed. Having regard, however, to the fact that exceedingly few American insects have succeeded in establishing themselves among us, the probability is that the potato-beetle would not find the Old World conditions suitable. The plum-weevil of America, as Professor Claypole points out, has taken possession of the introduced European stone fruits, and its ravages in America are enormous, but it has not yet crossed the Atlantic; the European Windsor bean in America is ravaged by a species of blister beetle, but in this country the latter is yet unknown;

and there are many other similar cases. "If the analogy of the majority," says the above observer, "may be trusted, there is ground for hope that with care those pernicious insects may be unable to injure the potato fields of Europe."

Animals have not, however, been the only emigrants to America. Along with their domesticated animals the early settlers brought with them many of the cultivated plants of Europe, with the seeds of which came also those of many Old World weeds. Thus were introduced the buttercup, water-cress, hemlock, ox-eye daisy, tansy, burdock, the red and white clovers, and a host of others; and not more surely did the white man displace the red man than did those European weeds drive westward before them the native occupants of the soil. English visitors to the States are generally as much struck by the resemblances as by the differences between the vegetation they see around them and that of the mother country; nor is this to be wondered at, since the roadside weeds of the New England States, to the number of one hundred and thirty, are, according to Agassiz, all European. A few of our common British wild plants, such as the daisy, cowslip, and primrose, have, however, hitherto failed to establish themselves in the New World.

While the whole of the North American continent is thus more or less overrun with English weeds, exceedingly few American weeds have succeeded in

obtaining a footing in Europe. These, according to Professor Claypole, may be counted on the fingers. The most important of them is the so-called "water thyme," which appeared simultaneously in several parts of Britain many years ago, and spread with amazing rapidity, destroying, according to one account, the beauty of many ornamental pieces of water, impairing the navigation of canals and sluggish streams, and choking the outlets of reservoirs. Several years ago large quantities of this Yankee weed had to be removed from the Edinburgh and Glasgow Canal.

To account for the exceptional success which has attended the emigrant plants and animals of Europe in the New World several theories have been started. American weeds accustomed to grow under the shadow of the primeval forest have, it is said, been unable to compete successfully, after the removal of the trees, with their European congeners accustomed to cleared ground; and this must no doubt have exercised some influence. That injurious insects should multiply faster and do more harm in their new home than in Europe may also be partly accounted for by the greater abundance of suitable food, and still more by the absence in many cases of the parasites which in their old homes kept them in check. The immense multiplication of the wheat-midge and the currant saw-fly, and the consequent increase in their power of doing mischief,

have been attributed to the fact that they succeeded, when emigrating, in leaving their parasitic enemies behind them, while they have not yet been attacked by any of the American forms. This immunity is probably, however, only temporary. Thus the cabbage-butterfly has lately been joined in its new home by one of its most pertinacious European foes, whose presence is already forming an effective check on the over-multiplication of its insect host.

Professor Claypole has advanced an ingenious theory, according to which he seeks to explain the backwardness of American and the forwardness of European life by a reference to an acknowledged difference in their past history. Palæontologists know that, so far as plant and animal life are concerned, the so-called New World is in reality the old. The native plants which now flourish in America find their nearest representatives in the fossil vegetation of the Miocene period in Europe. They were existing during that epoch in America, and they, or their immediate descendants, are living there still. In Europe, on the other hand, those antiquated forms have been long since superseded by a more highly developed flora. The latter, by reason of its youth, is more vigorous and plastic than the old-fashioned plant-life of the New World, and is therefore better fitted to win in the struggle for existence. The fact that a marsupial—the opossum—still lingers in America is proof enough of the ancient character of

the New World fauna. Such pouch-bearing animals once inhabited Europe, but epochs ago they gave place to higher forms; and this higher development of European life has given it the victory over the older life of the New World.

ming-bells, these having an inner coating of what has been described as "the earliest appearance in the animal kingdom of anything resembling muscular tissue." By the contraction of this rudimentary muscular surface the capacity of the bell is greatly reduced, water is consequently ejected from it backwards—a movement which has the effect of propelling the creature forwards.

Some of the species attain a large size, the swimming-bell in certain cases measuring upwards of two feet in diameter, and these are the forms dreaded by bathers on account of their well-known stinging properties. Their stinging weapons are chiefly the long tentacles attached to their mouths, and these continue to sting after they have been broken off from the parent body. Our seas possess several of these venomous forms, but they are altogether distanced in stinging power by tropical species. A naturalist states that when sailing among the Antilles he tried to secure one of these for examination. "Scarcely had I stretched out my hand," he says, "when it was suddenly enveloped by a network of tentacles, and after the first impression of cold, it seemed as if my arm had been plunged up to the shoulder in a caldron of boiling oil, so that I screamed with pain." They are thus said to secure their prey by first paralyzing it, and it is alleged that the larger forms in this way catch and devour creatures so much more highly organized than themselves as fishes.

If jelly-fishes are thus in some cases fish-devourers, it is still more certain that in other cases they play the part of fish-protectors. Mr. Peach, the veteran naturalist, who was one of the first to make the observation, states that at Peterhead he saw small fishes, when attacked or alarmed, running under the umbrella and among the tentacles of the jelly-fish for shelter, remaining there until the danger had passed, and then emerging again to sport and play around their protector. An American correspondent to *Nature* lately stated that as many as twenty individuals of a small species of fish were sometimes found under one of those pulsating umbrellas; while an Irish correspondent referred to an instance he had observed, in which the jelly-fish would occasionally turn on its back so as to evict its rentless tenant, with the result that no sooner did it regain its normal position than the fish returned to its old quarters.

These jelly-like organisms are also the principal cause of the phosphorescence of the sea—a phenomenon frequently observed in temperate waters, but most brilliantly displayed in the tropics.

To the physiologist these creatures are of special interest, as being the lowest in which a nervous system has yet been discovered, and they thereby afford him a field in which to study the genesis of nerves. Until lately, the existence of such a system in creatures so near the bottom of the animal ladder was deemed very problematical. Mr. G. J. Romanes

has, however, by his recent vivisectional experiments, shown that the minute bodies known as "marginal vesicles," placed round the edge of the bell, are in reality nerve-centres. By merely cutting off the extreme edge of the bell containing these marginal bodies he found that the previously active movements of the swimming-bell were suddenly and finally stopped, while the narrow margin which had been severed from it "continued its rhythmical motions with a vigour and a pertinacity not in the least impaired by its severance from the main organism"—an activity which seems to have continued for days after the operation.

It was thus proved that the pulsating movements in the bell of the jelly-fish were wholly due to the presence of those nervous centres in the margin.

In the great majority of those creatures no trace of nerves could be distinguished. That these, however, must exist, although in an exceedingly rudimentary condition, would appear from the fact that if the bell of certain forms—not the lowest—be pricked with a needle, the centre stalk containing the mouth immediately moves over and touches the point irritated. This would seem to show that the stimulus arising from the pricking had travelled in a definite channel, and thus enabled the central organ to localize the seat of stimulation.

Mr. Romanes found species in which the nervous

system was not developed to the extent of thus being able to localize a given point; while he found others in which the evolution of the nervous system had proceeded a step further, actual nerve-fibres for the conveyance of *stimuli* being for the first time visible in the animal kingdom. He also found that those jelly-fishes with nerves and nerve-centres had the power, not possessed by others, of steering themselves in any given direction. Comparatively complex as the structure of some of those creatures is, they are, after all, little more than animated masses of sea-water. Farmers have been known to cart them away from the sea-shore as manure; but that they could be of little service for this purpose will appear when it is stated that a ton of these organisms does not contain more than four pounds weight of solid material.

Until lately (June 1880) jelly-fishes were supposed to be, without exception, marine animals. Zoologists were accordingly considerably fluttered by the announcement of the discovery of an undoubtedly fresh-water species in great abundance in the water-lily tank in the gardens of the Botanical Society, Regent's Park, London. Specimens were placed in the hands of Professors Allman and Lankester, and the importance attaching to this new form of jelly-fish may be gathered from the fact that seven days after its discovery it had a generic and a specific name all to itself, besides a

couple of *aliases* known in scientific language as synonyms.

This unique form is of small size, its bell not exceeding half an inch in diameter, and is very energetic in its movements. It is evidently a tropical form, as it lives and thrives in water having a temperature of ninety degrees Fahrenheit. In this respect it differs greatly from marine jelly-fish, all of which die on exposure to a temperature exceeding seventy degrees. It differs from these likewise in being much less tolerant of cold. Freezing kills it; whereas, according to Romanes, the marine forms may be frozen solid, and when gradually thawed they will resume their characteristic movement. The same investigator found similar evidence of a nervous system in this as in previous forms.

Seeing that jelly-fishes are, so far as known, with a single exception, marine, it may be presumed that in the fresh-water form we have the modified descendant of a salt-water ancestor. Experiment, however, shows that the fresh-water form is more intolerant of salt water than are the marine forms of fresh water. A sea jelly-fish will survive immersion in fresh water often for ten minutes; whereas if the fresh-water species be placed in salt water—its ancestral element—for a single minute, it is almost certain to die within an hour or two after returning to its normal element. By diluting the sea water, however, with a large proportion of fresh water,

the creature can exist in it for a considerable time.

The passage from the marine to the fresh-water jelly-fish must have been by exceedingly slow degrees, probably brought about, as Mr. Romanes suggests, "by the ancestors of the fresh-water medusa (that is jelly-fish) penetrating higher and higher through the brackish waters of estuaries into the fresh water of rivers." That such modifications as may be presumed to have thus taken place in the past, in the transformation of a purely marine into a purely fresh-water jelly-fish, are still being effected, seems probable from a statement of Mr. Moseley's in his "Notes of a Naturalist on the *Challenger*." Describing a long narrow creek near Sydney, at the head of which the salt water of the ocean was so mixed with fresh as to be drinkable, he says: "Here are the most favourable conditions possible for turning marine animals into fresh-water animals; in fact, the change of mode of life presents no difficulty. Below, no doubt, the water is always salt, but the fish find a fluid gradually less and less salt as they rise to the surface. We caught the mullets in almost fresh water. The oysters were flourishing in the same water, and with them the mussels and crabs. I even saw an abundance of medusæ (jelly-fish) swimming in the creek above the sand-flats, where there was scarcely any salt at all in the water, yet evidently in most perfect health."

There is, however, at least one case known of a marine, or, at least, brackish-water animal having within recent years accustomed itself to purely fresh-water conditions. A polyp (*Cordylophora lacustris*), which thirty years ago was only found in estuaries, has since migrated into several Continental rivers. It is now found in the Seine at Paris, and in the fresh-water aquarium of the Jardin des Plantes; also in the Elbe, from which it entered the water-pipes of the city of Hamburg, and so flourished as seriously to impede the flow of water.

XIII.

GIANT CUTTLE-FISHES.

THE popular idea that the animal world now contains fewer gigantic forms than it did in former geological periods has little or no foundation in fact. There were, no doubt, giants in those days, but there are undoubtedly giants still; and our whales and sharks, our Jumbos and giraffes, will bear comparison with those of any former period. In reptiles alone we seem to have gone back; but even here the great sea-serpent may yet come to the rescue and confound, by its size, the ancient saurians.

The story of the recent discovery in Canadian waters of giant cuttle-fish, or devil-fish, as our American cousins prefer to call them, inclines one to take a somewhat hopeful view of the sea-serpent question. Traditions of the occurrence of colossal squids are not uncommon among maritime nations. Pliny tells of the capture of one on the coast of Spain by a Roman general, the head of which was as big as a cask, while one of its ten arms measured

thirty feet in length, and had suckers on it as big as small basins.

This was diminutive, however, compared with the legendary kraken of the Scandinavian coast—a giant octopus, whose back, according to the Norse fishermen, looked, as it appeared above the water, like a number of small islands; and whose arms, rising above the surface like the masts of a vessel, had power to grasp the largest man-of-war and pull it to the bottom. Linnæus believed in this fabulous monster, and in natural history works of his time the kraken was usually figured with a three-masted vessel in its deadly embrace.

The accounts given by various voyagers during the present century of having seen huge cuttle-fishes, and the fragments of these occasionally brought home, convinced naturalists that the kraken had at least some foundation in fact. It is only, however, during the past few years that the extent of this foundation has been fully ascertained by the capture and measurement of several of those huge sea-monsters.

In 1873, three fishermen, when plying their vocation off the Newfoundland coast, saw a shapeless mass floating on the water near them; and thinking it might prove part of the cargo of a shipwrecked vessel, they rowed up to and struck it with their boat-hook. "In an instant," says the Rev. Mr. Harvey, to whom science is indebted for the

story, "the dark mass became animated, and, opening out like a huge umbrella, displayed to view a pair of prominent ghastly green eyes of enormous size, which glared at them with apparent ferocity, its huge parrot-like beak at the same time opening in a savage and threatening manner."

Before the men had sufficiently recovered their presence of mind to think of endeavouring to escape, the creature shot out several of its long fleshy arms towards their boat, and two of these had already laid firm hold of it, when one of the fishermen, seizing a hatchet succeeded in lopping them off. Finding itself wounded, the monster withdrew, blackening the water as it went by the emission of its inky fluid, while the fishermen made for the harbour with the two trophies of their encounter.

One of these was destroyed before Mr. Harvey reached the scene; the other measured nineteen feet in length; six feet of it, however, had been previously cut off, while the fishermen calculated that about ten feet more of it had been left on the monster. The entire arm must therefore have measured nearly forty feet in length; and if twenty feet be added for the body, we have this gigantic mollusk—for it belongs to the same class of animals as the oyster and the whelk, and is no fish—rivalling in length an ordinary whale.

Cuttle-fishes have ten arms, two of them much longer than the others, arranged in a circle round the

head, with the mouth—which is provided with a parrot-like beak—lying in the centre. It was one of the two long arms which Mr. Harvey rescued; and this he found studded over with no fewer than one hundred and eighty cup-like suckers, some of them an inch and a quarter in diameter. Beneath each of these suckers a vacuum is formed when the animal grasps an object—a fact which sufficiently explains the invincible tenacity of its hold.

Since the date of the above-mentioned encounter, many other specimens of giant cuttle-fishes have been taken in the same neighbourhood. Shortly after, one was captured in a net by three fishermen, and it was only after a severe struggle that they succeeded in landing their "sea-devil." Its body was eight feet in length and five feet in girth, while its longest arms measured twenty-four feet. Its parrot-like beak was as big as a man's fist, and the sockets of its fishy eyes had a diameter of four inches. The entire specimen was taken to St. John's, Newfoundland, where it was photographed and the huge carcass preserved.

A living specimen was also found in shallow water at Coombe's Cove; but it was, for the most part, destroyed by the fishermen. From what remained Professor Verrill, who has scientifically investigated the subject, states that it must have exceeded forty feet in length.

In 1877 a huge squid was cast ashore alive in

Catalina Bay, and was afterwards conveyed in brine to the New York Aquarium. It is the largest and best specimen yet preserved, its body measuring nine and a half feet in length and seven feet in circumference, while its pair of long arms measured thirty feet each. The upper part of its beak was half a foot in length, while the sockets of its eyes measured no less than eight inches across.

During the same year another fine specimen ran ashore in Trinity Bay. It had been borne in by a spring-tide, and when first seen was struggling desperately to escape from the shallow water. "In its struggles," says the writer of the account, "it ploughed up a trench or furrow about thirty feet long and of considerable depth by means of the stream of water that it ejected with great force from its siphon." On the tide receding it died, when its carcass was found to have a total length of forty-four feet. The siphon referred to above is the opening by which the creature ejects the water which has been used in the gills for purifying its blood. The stream of effete water is further utilized as the creature's chief means of locomotion. Issuing with great force, the water propels the cuttle-fish in a direction opposite to its own current, just as the motion of the rocket through the sky is effected.

A year later another "devil-fish" was encountered by Newfoundland fishermen not far from the shore. It had, like the previous one, got into shallow water,

and was making desperate efforts to escape, churning the water into foam by the motion of its arms and body, and in its excitement discolouring the surrounding sea by the emission of its inky secretion. Finding it thus partially disabled, the seamen approached sufficiently near to throw upon it the grapnel of their boat, the barbed flukes of which sank into its molluscous body.

Proceeding to the shore with the rope attached to the grapnel, they fixed it to a tree, and thus moored the briny monster to the shore. "His struggles," says Mr. Harvey, "were terrific, as he flung his ten arms about in dying agony." This specimen, which appears to have been the largest yet seen, measuring about fifty-five feet from tip of arm to extremity of body, was not preserved, the fishermen cutting it up for dog's meat. Another specimen, nearly thirty-eight feet in length, was caught in December 1879, while the latest capture was made in November 1881. It measured only twenty-eight feet, and was taken in Portugal Bay, from which it was conveyed to New York encased in ice.

Although these giant cuttle-fishes have all been found in the neighbourhood of Newfoundland, there is authentic evidence of their occurrence also, within recent years, in European waters. In 1861, a squid, measuring about thirty feet in length, was encountered by a French corvette between Madeira and Teneriffe, and after a protracted fight the

creature was at length noosed. On attempting, however, to bring it on board, its enormous weight caused the rope to cut it completely through, and all but the posterior end was lost.

Professor Steenstrup many years ago gave an account of a specimen which was stranded on the Jutland coast in 1854. Unfortunately, it was cut up at the time by the fishermen for bait, and no more could be learned of its size than that its remains had filled a large cart. A few years later the mutilated carcass of a large specimen was found stranded on one of the Shetland Islands. It measured altogether twenty-three feet in length, the body alone measuring seven feet. This remained the largest recorded British specimen until the autumn of 1880, when a still larger was cast ashore, during a storm, at Kilkee, on the Irish coast. It was an octopus—the name applied to the eight-armed forms—and was said to be about thirty feet long, its suckers being nearly the size of a shilling.

It is somewhat remarkable that with such monsters undoubtedly occurring in the deep, so little should have been seen of them. The ordinary cuttle-fishes of our coasts are exceedingly prolific, depositing, it is said, about forty thousand eggs; and it is not probable that in this respect the giants differ from their pigmy brethren. That they are not oftener seen is probably due to their frequenting the open ocean—those found inshore being either dead

or sickly; and to the fact that they do not, like whales, need to come to the surface to breathe—whole shoals may thus pass beneath a ship without attracting notice.

They are believed to prey chiefly on fish, their size, weapons, and speed rendering them formidable to all but the largest marine species. There is considerable evidence to show that they, in turn, are preyed upon by those leviathans of the ocean the spermaceti and other toothed whales. They constitute also a danger to divers and bathers. A comparatively small species—about six feet long—which occurs among the Polynesian Islands is greatly dreaded by the natives, who dive for shell-fish.

Some years ago a diver, engaged upon a wreck off the coast of Florida, was seized by a huge octopus, and grasped so firmly that, as he expressed it, he felt himself "being cracked into a jelly." Happily, he was being raised to the surface at the time, and thus probably escaped death. His companions laid hold of one of the creature's arms, but their combined strength was insufficient to overcome the adhesion of a single sucker, and it only released its grasp on its body being vigorously attacked.

That those monsters will even attack boats, like the legendary kraken, was shown in the case of the first Newfoundland specimen above referred to. Another case has since been chronicled, in which a cuttle-fish twenty-one feet long laid hold of a fish-

ing-boat off the Japanese coast, the occupants of which, however, succeeded in killing the monster. With a hatchet on board there is no difficulty in getting rid of those unwelcome visitors, and the Newfoundland fishermen, we have been told, invariably take this weapon with them to sea.

XIV.

MIND IN FISHES.

THAT fishes are not mentally endowed to the same extent as mammals, birds, or even reptiles, is true, and is due to their lower organization and less developed brains. Neither, however, do they lead the almost vegetative lives they have been generally supposed to do, better acquaintance of late years with their habits having shown them to be possessed of considerable intelligence, and to be subject to like passions with the higher animals.

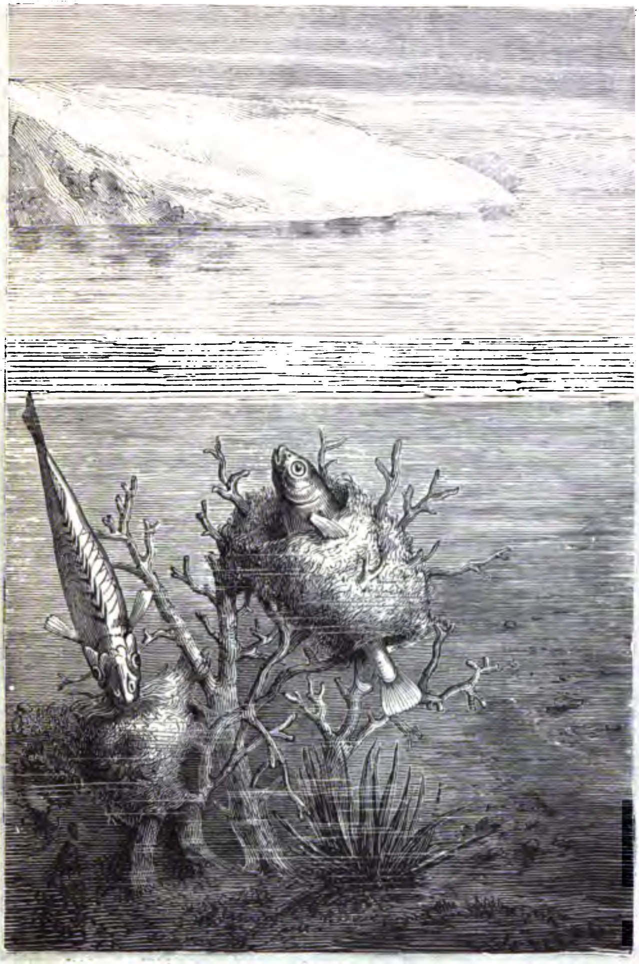
Affection for their young characterizes many species; and nest-building, which forms so pleasing a feature of bird life, is not unknown among fish. In our own waters, the various species of sticklebacks, both marine and fresh-water, build nests of sea-weed and other vegetable fibres, that of the fifteen-spined species forming "a pear-shaped mass as big as a man's fist," held together by an elastic silky thread.

Still more curious is the nest of the Chinese

butterfly fish, recently described by a French naturalist. It is of considerable size, and is made of froth, which the male fish prepares by mixing air-bubbles with mucous matter from its mouth. Should the latter material fail, it has only to descend to the bottom and chew certain weeds in order to stimulate further secretion. In raising the eggs of the female from the bottom, the male of this species has recourse to a most ingenious mechanical device. Swallowing as much air as it can, it descends to the bottom, places itself beneath the eggs, and then expels the air by its gills in two fine streams. The gas thus liberated surrounds the eggs and takes them with it to the surface.

The parental solicitude of fishes is further seen in the care with which they guard both their eggs and the newly-hatched young. Mr. F. Day, who has lately brought together much information on this subject, tells of a fish found in the Black Sea, the male and female of which unite in building a nest. In this, he says, "the female not only lays her eggs, but watches them carefully like a hen; and when the little ones are hatched they remain near the mother till they are sufficiently grown to venture forth alone into the world of waters."

Among fish, however, the duty of nest-building and of nursing seems to fall mainly upon the male; the mother, in the case of the sticklebacks, being usually driven away as soon as its eggs are depos-



NESTS OF FIFTEEN-SPINED STICKLEBACKS.

ited. The gouramy, a Mauritian fish, keeps constant guard over its nest during the entire period—a month—of hatching, and the fry are not relieved from parental supervision till some time after.

Their attachment to their young is further seen in the courage with which many species defend them when in danger. The tiny three-spined stickleback has been seen to attack and beat off a couple of tench and a carp twenty times its size, when they were endeavouring to seize its young. Under such circumstances they will even strike at man.

A resident in Trinidad recently described how, on entering a stream to bathe, a small and usually shy fish darted forward and repeatedly struck at his hand. Astonished at its unprecedented boldness, he set himself to watch the movements of the fish in order to discover the cause, when, in a small hollow about the size of an egg, artistically excavated from the bright quartz sand, he saw a multitude of tiny fish huddled together, apparently newly hatched, over which the parent kept jealous watch. Next day he returned to the spot, but found that in the interval the parent fish, apprehensive of danger, had excavated a fresh nest some distance away, and had conveyed thither its brood. He also found that any attempt to introduce his finger into the nest was resisted by the fish with all its might.

There are certain species of tropical sheat-fishes

which do not build nests, but the males of which have the extraordinary habit of carrying the eggs of the female in their mouths. Mr. Day has found the eggs in this position in all stages of development, and is therefore inclined to the view that they are thus carried during the entire period of incubation. Dr. Günther has also described a fish from Lake Tiberias, in which this seems undoubtedly to be the case, the young even remaining in the mouth some time after they are hatched. There are other fish, known as hippocampi and pipe-fish, in which the male carries the eggs in a sort of pouch until they are hatched, and into which the young are said to retreat when in danger.

That many fishes thus exhibit a lively affection for their offspring is evident. They seem, however, to be equally capable of attachment to each other, and in some cases even to man. Jesse tells of a pair of golden carp which became so attached to each other that when one was removed the other refused food and pined until its companion was brought back, when it at once regained its former spirits.

Individuals of such species as the carp, trout, tench, eel, and cod, have become sufficiently familiar with man to take food from his hand, while they have intelligence enough to learn to come for food at the ringing of a bell or the sound of a whistle. Intelligence is also visible in the methods adopted

by many species in the capture of their prey; as when the angler and the star-gazer, burying themselves in the mud, wave about the tentacles surrounding their mouths, so as to delude the smaller fish into the belief that these appendages are worms, and so induce them to come within reach of their crafty enemies.

Still more wonderful is the method adopted by the jaculator fish, an inhabitant of the shores and estuaries of tropical Asia. No sooner does it see a fly resting on a plant growing out of the water than it approaches within five or six feet of it; then taking steady aim it ejects with unerring precision a single drop of water from its long tubular mouth, which almost invariably brings down the fly.

There are likewise instances on record in which fish have shown a fertility of resource that would seem to indicate a certain amount of reasoning power. The curator of the Manchester Aquarium recently stated that a skate in one of the tanks being unable, owing to the position of its mouth on the under surface of the body, to reach some food that had fallen into a corner of the tank, lay quietly for some time, as if thinking. Then raising its body into a slanting position, with its head upward and its under surface towards the food, it began moving its broad expanse of fins, and thus created an upward current which carried the coveted morsel right up to its mouth.

Fish belonging to totally different groups seem also to have the intelligence to combine for the attainment of a common end. Thus there are several accounts of the whale being attacked by the thresher shark and the sword-fish conjointly; while there is considerable evidence in favour of the view that some sort of partnership obtains between the pilot-fish and the blue shark. The latter is frequently seen following in the wake of ships accompanied by several pilot-fishes. On one occasion, when a tempting bait was held out to the shark, those followers seemed to be doing what they could to prevent him taking it and thus getting hooked. At length, however, he managed to elude their vigilance, and, seizing the bait, was caught. On being hauled up, it was observed that one of the pilot-fish clung to his side till he was completely out of the water.

Anger is one of the emotions to which fish are subject, and it is one to which they give visible expression in a variety of ways. A spiny-rayed fish, when thus excited, at once raises its fins and spines—even its scales become elevated, just as the hairs of mammals and the feathers of birds get stiff with rage; while many species under similar excitement change their colour.

One of the most pugnacious of animals is the fighting-fish of Siam, which when at rest is comparatively dull-coloured. It has only to be brought

into the presence of another individual, or even of its own image in a mirror, in order to become a picture of rage, its raised fins and the whole body beginning to shine with metallic colours of dazzling beauty. The same heightened colour is seen in male sticklebacks when engaged in combat; and when the fight is over, it is observable that while the conqueror retains this bright colouring, or even grows more splendid, his vanquished opponent loses all his brilliancy.

The colours of fish are brightest during the breeding season; and it was recently observed by two American naturalists, with regard to a fresh-water perch, that the introduction of a female into an aquarium produced an almost instantaneous change in the pattern of the colouring in the male of the same species.

Fishes feel terror, and it is probably under its influence that certain species emit sounds. Darwin states that a South American fish, the armado, emits, when caught on the hook, a harsh, grating noise, that can be heard distinctly when it is beneath the water; and herrings, when the net is drawn over them, are said to give vent to their feelings in a similar way. Other fish, however, are known to emit voluntary sounds that may even be classed as musical, which, as they are generally most frequent and loudest during the breeding season, Darwin is inclined to regard as love-calls.

left behind; it may, therefore, be fairly enough inferred that for every herring taken by man the cod takes ten.

The cod, however, is but one of an immense host of fish-eating species, such as the hake, from which as many as seventeen pilchards have been taken, and the angler—perhaps the most voracious of all, and certainly one of the best equipped for fish-capturing purposes—from the stomach of one of which more than fifty herrings, sufficiently fresh to be sold in the market, have been taken.

If fish are thus their own worst enemies, birds probably come next as destroyers of fish life. Gulls, terns, gannets, divers, cormorants, skuas, and auks among sea-birds, and the osprey, or fishing hawk, among land-birds, are all actively engaged in the capture of fishes.

The gannet in Britain is only found around St. Kilda, the Bass Rock, and Ailsa Craig; yet, according to the report of a recent Commission on the Herring Fishery, the Scottish gannets alone are believed to consume about a thousand million of herring annually—as large a number, probably, as is taken in the same time by the Scottish fishermen. The gannets follow the herring shoals as they approach the coast, and they thus form a valuable guide to the fishermen on the outlook for the herring harvest.

Their method of capturing them is thus described by Professor A. Newton: "Flying in a line, each

bird, when it comes over the shoal, closes its wings and dashes perpendicularly into the waves, whence it emerges after a few seconds, and, shaking the water from its feathers, mounts in a wide curve and, orderly, takes its place in the rear of the string, to repeat its headlong plunge as soon as it again finds itself above its prey." Divers and cormorants fish in a different way: diving beneath the surface, they shoot through the water in pursuit of their prey, much as a cod or a dog-fish would do.

All web-footed birds seize their scaly prey with their bills; the osprey, or fishing hawk, on the other hand, makes use for this purpose of its powerful talons. Observing, as it sails majestically in the air, its aquatic quarry, the osprey suddenly precipitates itself upon it from a height of about fifty feet, and often captures the fish without apparently wetting more than its feet. Diving is not much in its way, as it cannot swim; occasionally, however, it plunges overhead in its eagerness to clutch its scaly victim.

One of the rarest of British birds, the osprey is comparatively common in North America, where its success as a fisher is often neutralized by the thieving propensities of the American bird of liberty—the bald eagle. Watching its opportunity, the latter swoops down upon the osprey as it rises from the water, and generally succeeds in robbing it of its quarry.

The bald eagle is not alone among sea-birds in

[illegible] may [illegible] and canals of China, [illegible] the market with fish. When the fishing-ground is reached, the cormorants, at a signal from their master, enter the water, and scattering themselves about, commence operations. As soon as a fish is caught, the [illegible]ses to the surface with it, and is at once

called to the boat by the alert Chinaman. Obedient to the call, it approaches, and is taken into the boat, where it disgorges the fish, and is again ordered into the water.

Thoroughly trained as those fishing cormorants are, nature would no doubt assert itself, and the captured fish be swallowed, were the necks of the birds not bound with a strap, drawn sufficiently tight to prevent the passage of the fish. Sometimes the fish caught is too large for a single cormorant to "land,"—a dilemma from which the bird is usually delivered by the arrival of one or more cormorants, which together haul the fish to the boat.

Should the birds get lazy or playful, and swim about without attending to their business, the Chinaman, according to Fortune ("Wanderings in China"), with a long bamboo strikes the water near the bird, without, however, hurting it, calling to it at the same time in an angry tone. "Immediately," he says, "like the truant schoolboy who neglects his lessons and is found out, the cormorant gives up his play and resumes his labours."

Fish are both abundant and cheap in China, due mainly to the universal practice of fish culture among the Celestials; yet it was recently stated that from twenty to thirty of these birds will catch six francs' worth of fish daily. It is not surprising, therefore, that a pair of well-trained cormorants should fetch a high price—about one hundred and

sixty francs. Fishing with cormorants appears to have been practised by the Chinese from very early times, and it was probably through intercourse with them that the art was introduced into Europe three centuries ago.

The European cormorant is a different species from that found in China, being altogether a larger bird. Its habits, however, are similar, and it is equally capable of being trained to catch fish for its master. In the time of James I., who was himself exceedingly fond of the amusement, a Master of the Royal Cormorants was appointed, who was paid £30 "for his trouble in bringing up and training of certain fowls called cormorants, and making them fit for the use of fishing."

During the civil war which preceded the Commonwealth, this sport, like many others, disappeared, and it was not revived until the year 1847, when Captain F. H. Salvin commenced the training of cormorants for this purpose. So well did he succeed that, two years later, when he made a tour through the northern counties of England with four cormorants, he took one thousand two hundred good-sized fish in twenty-eight days; while on one occasion forty-five fine trout, weighing twenty pounds, were thus captured in seven hours. With his cormorants he has taken, he says, almost all the fresh-water fishes from a minnow to a pike, and in brackish water near the sea he has taken flounders.

As in the Chinese birds, a strap is buckled round the lower part of the cormorant's neck to prevent the downward passage of the fish. In the case of eels, however, it is hardly possible to prevent them getting down, and as cormorants are exceedingly fond of these fish, waters abounding in eels are not suitable for this mode of fishing.

Cormorants cannot deal effectively with fishes over two pounds in weight; when larger individuals are caught, they are carefully worked round with the creature's beak until the fish is in a position to be gulped down head foremost. Smaller specimens are tossed up in the air and dexterously caught, head foremost, in the mouth.

In clear water the sport is most interesting to the onlooker, as he can readily follow with his eyes the tactics of the cormorant. A correspondent of the *Field*, describing a recent trial of cormorant fishing at Midhurst, states that he thus watched the movements of an old bird, which, from experience, had evidently grown cunning. It probed all the likely holes and crevices in expectation of a trout, and when one at last appeared, gave chase and soon caught it. Having seized it, however, too near the tail, the fish made its escape into the water. Continuing the pursuit, it again caught the trout, this time in a position that enabled the cormorant to swallow it in the usual head-foremost way. Landing with its prize, it yielded up the trout to its

master, who rewarded it with a piece of chopped fish.

Fishes have a great dread of the cormorant, and they have been known, when pursued by those birds, to seek safety by throwing themselves on land. The cormorant appears to be a long-lived bird, Captain Salvin having a pair with which he has been fishing regularly from year to year, one of which is nineteen and the other eight years old. During the winter of 1881 he deposited those birds at the Zoological Gardens, London, and early in the spring of last year they built a nest, in which the female deposited three eggs, and a month after two young birds were hatched—the first instance in Europe of the breeding of domesticated cormorants.

Plenty of wild cormorants may be obtained from the nest in July on most of the rocky parts of the British coast. In order to prevent their flight, the long feathers of the left wing are usually cut within two inches of the bone, while great care ought to be taken, according to Captain Salvin, to keep the tail as perfect as possible, this organ being of the greatest assistance to the bird in diving.

The number of fishing mammals, excluding man, is very considerable, comprising whales, porpoises, dolphins, seals, and others. Whales, sometimes in hundreds, feed on the outskirts of herring and other fish shoals; and the Norwegian fishermen calculate the dimensions of these "schools" by the extent of

this cetacean fringe. Seals keep close to the coast, where they are the most deadly enemies of the salmon.

The otter feeds chiefly on trout, eels, and to some extent on salmon. Such authorities as Charles St. John, however, do not regard the otter as by any means so destructive of salmon as many suppose. Eels and trout, on which it chiefly feeds, destroy enormous quantities of salmon eggs, and the otter, in keeping down their numbers, probably compensates for the direct injury it does to the salmon.

As in the case of the cormorant, the fishing proclivities of the otter have been turned to account by man. When taken young it can be readily tamed; Captain Salvin thus had one which followed him into the country like a dog. By careful training they can soon be taught to fish on their master's account, and an otter has been known to capture and bring home eight or ten salmon in a day.

Mr. St. John tells of one caught when half grown, and trained to fish for trout, a dozen of which it would take out of a stream in the course of a forenoon. Its food, he states, consisted in general of porridge and milk, which it took with apparently as much relish as fish.

Fishermen in some parts of India employ a smaller species of otter, not only in catching fish, but in driving the shoals into their nets.

XVI.

THE FOOD OF SEA-FISHES.

THE vegetarian, in the midst of a beef-eating generation, may at least console himself with the thought that butcher meat consists solely of the carcasses of vegetarian animals. So much, however, cannot be said of the five hundred thousand tons of fish annually consumed in the United Kingdom, our food-fish being wholly animal feeders. There are a few herbivorous fish in the sea, but the work of utilizing ocean vegetation for feeding purposes is for the most part left to shell-fish and other forms of invertebrate life, which are in turn preyed upon by fish.

Food, it has been said, makes the man. It would be less difficult, however, to show that it makes the fish. It is the crustacean diet upon which, at certain seasons, many of the salmon family almost exclusively subsist, that gives their flesh the well-known salmon colour. The herrings of Loch Fyne and the other sea lochs of our west coast owe their marked superiority in flavour over the *Clupeas* of

the east coast to the much better feeding-grounds in those sheltered inlets. Poisonous fishes, of which there are a goodly number, including two species of herrings and the entire fish fauna of a certain coral bank off the Bermudas, owe their deleterious qualities solely to the poisonous nature of their food.

The size of fishes depends in an unusual degree on the nature and supply of their food, mature individuals belonging to the same species often showing a disparity in size probably unequalled in any other division of the animal kingdom. Adult salmon thus vary from a few pounds weight to such monsters as that weighing seventy pounds, a cast of which was exhibited at the Edinburgh Fisheries Exhibition. Carp have been known in Germany to grow to a length of nine feet, and to weigh seventy pounds; while a pike was caught many years ago in Loch Lomond which weighed seventy-nine pounds, and another in the Shannon weighing ninety-two pounds. The halibut—the giant representative of the flat-fish family—shows similar contrasts, mature individuals varying from a few pounds weight up to six hundred pounds, the recorded weight of a specimen taken off the New England coast.

The writer has taken dozens of trout from a mountain tarn in Arran, not one of which weighed more than four ounces, and he never knew of larger specimens being obtained there. In a basin of granite surrounded by peat bogs, and too high for much

insect life, food was necessarily scarce, and these dwarf trouts were the result. The same thing occurs, according to Günther, when the young of coast-fishes get driven out to sea, where the supply of food is much less than in-shore, the fish, in such cases, usually remaining in an undeveloped condition.

There are many fishes, however, as the herring, mackerel, and pilchard, which grow rapidly and regularly to their specific size, their further growth being arrested; and these, it has been observed, are generally short-lived species. The fish of slow and irregular growth, growing apparently to an indefinite size, are, on the other hand, long-lived, the term of life in such fish as the carp and pike having been ascertained to exceed a hundred years.

Although the food of sea-fishes is almost wholly animal, it varies considerably in different groups. Thus dog-fish, cod, halibut, and other fishes of prey, pursue and devour the smaller fish, and, in some cases, even their own young. Ground-feeding forms, such as most of the flat-fish, live largely on worms and shell-fish. The minute forms of crustacea are the favourite food of herring, pilchards, mackerel, and sprats; while others, as the wolf or cat-fish, have teeth specially adapted for crushing the shells of mollusks.

Many sea-fish, however, are omnivorous, while all are extremely voracious. Mr. Day, in his work on "British Fishes," gives sufficiently striking examples of their gastronomic powers. A guillemot, partridge,

hare, turnip, a bunch of keys, and a book, have been taken at different times from the stomach of a cod. Mr. Reid, of Wick, took out of another cod, in May 1878, no fewer than thirty-two herrings, all of them nearly entire. This same observer took a salmon twenty-seven inches in length out of a ling six feet long.

The ling, like the cod, appears to swallow the most miscellaneous material. Thus, one captured off Brandon Head, Kerry, in 1881, which weighed twenty-five pounds, was found to have in its stomach a three-gill bottle, some herrings, and a young cod. "There were also," says Mr. Day, "several pieces of parchment and bits of sealing-wax, which induce the supposition that the fish had swallowed one of those mournful messages of shipwreck."

Both cod and ling, however, feed largely on herring during their season, and Professor Huxley states that it is a very common thing to find six or seven large herrings in the stomach of a cod, not one of which has been long enough there to be digested. The angler is a still more voracious fish, employing itself when caught in the net in swallowing as many of its fellow-prisoners as it can. Wholly worthless as food, fishermen capture it for the sake of the undigested contents of its capacious stomach.

In connection with this voracity of sea-fishes, it is a fact noted by Günther that, while fresh-water

fishes can subsist for months without food, marine forms, as a rule, die of hunger in a few days.

The subject of the food of sea-fishes is at present receiving considerable attention, as it is believed that full information on this point will throw light on questions connected with the distribution and migration of fishes. It has been observed by whalers that where whale food exists, there, and there only, are whales to be found, and it seems to be equally true that fish follow their food.

It has been observed by United States fishermen that during the feeding season cod are only plentiful where food is abundant, and that after "cleaning up" one part of a "bank" they go to another. That they travel long distances in this search for food has been proved by the capture of cod off the New England coast, having hooks of a peculiar kind in their mouths. Such hooks are only known to be used by French fishermen on the Newfoundland banks; these hooked individuals must, therefore, have migrated southwards from five hundred to eight hundred miles. Cod are also known to follow shoals of the smaller fish for long distances, feeding upon them until the "schools" are destroyed or dispersed.

The food of fishes is by no means equally distributed, either over the ocean floor or on its surface. Deep-sea investigations have shown that, as on land, so in the deep there are great areas of comparatively

barren ground over which the fish pass on their way to different feeding grounds. These oases in the submarine deserts are frequently banks, which rise considerably above the level of the surrounding ocean floor.

It is the abundance of food, for example, on the Newfoundland banks which renders them the favourite resort of the cod. That abundance is attributed to the lower temperature of the water on the banks than at similar depths outside, which enables many subarctic shells and crustaceans to flourish there far south of their ordinary habitats.

It is a somewhat remarkable fact that a similar state of matters has been found to prevail on the Dogger—the great fishing bank of the North Sea. A knowledge of those populous places—the store-houses of fish-food—in British waters is essential, if the great sea harvest is to be thoroughly gathered.

The waters of the ocean, however, contain a large floating population, chiefly of minute forms of animal life, and the presence of these in enormous shoals has an important influence on the abundance of fish life. The so-called "herring food" consists of minute crustaceans, which occur sometimes in such prodigious numbers as to discolour the water for miles, so that every sweep of the tow-net secures tens of thousands.

During the summer of 1880, when off the Butt of Lewis, the naturalists on board the *Knight Errant*

dragged the tow-net at a depth of from seven to ten fathoms, when it came up filled with a mass of yellow slime, composed entirely of what Mr. Murray regards as algæ. Another haul of the tow-net at a slightly increased depth gave vast numbers of larval crabs and other crustaceans, the stomachs of which were found to be crammed with the algæ which floated overhead, while an examination of the herring and mackerel caught in the vicinity showed that they in turn were feeding on the minute crustaceans. Such a case fully justifies Mr. Murray's remark that a knowledge of the food supply of these fishes, and of the conditions to which it is subject, would probably give the key to the solution of the mystery which at present surrounds the migration of many of those fishes.

Professor Sars has investigated the subject of "Herring-food"—or *Aat,* as it is called by the Norwegian fishermen,—having every day, during a voyage from Norway to the Faroe Islands, found the sea filled with enormous masses of this living food. His investigations have led him to explain the irregularities in the spring herring fisheries of Scandinavia on the supposition that when the "food" is near the coast, the herrings reach the spawning ground before their milt and roe are matured. Their stay is thus prolonged; they enter the fiords and inlets, and a good fishing season is the result. When, however, the herring food is far away from

the coast, the milt and roe of the migratory fish get matured on the way to the spawning ground; and no sooner is this reached than the operation is performed, the exhausted shoals immediately retire from the coast, and the fisherman has thus little or no opportunity of reaping the herring harvest.

The favourite "herring food" is of a red colour. Professor Sars, during his voyage to the Faroes, found occasionally large masses of a blue "herring food," consisting of a different species of minute animal. This he named "mackerel food," as probably forming the principal food of the mackerels at those seasons of the year when they are not near the coast.

Whatever may be the food of the mackerel out in the open sea, there can be little doubt that it approaches our shores in pursuit of the young of the herring, pilchard, and sprat. Nor does the herring, when near the coast, confine itself to minute crustaceous food. Mr. Dunn of Mevagissey examined last summer (1882) the stomachs of herring during their period of recuperation after the long fast of the spawning time, and he found that it varied from worms to sand-launces and shrimps; while the stomachs of all the herrings caught by a fleet of boats for nights together were found to be gorged with young fishes, afterwards identified as crystal gobies.

The food of sea-fishes can hardly yet be said to

have formed the subject of systematic observation. It is to be hoped that the International Fisheries Exhibition will have the effect of drawing renewed attention to it, as a matter which has a very direct bearing on the successful prosecution of the sea fisheries.

XVII.

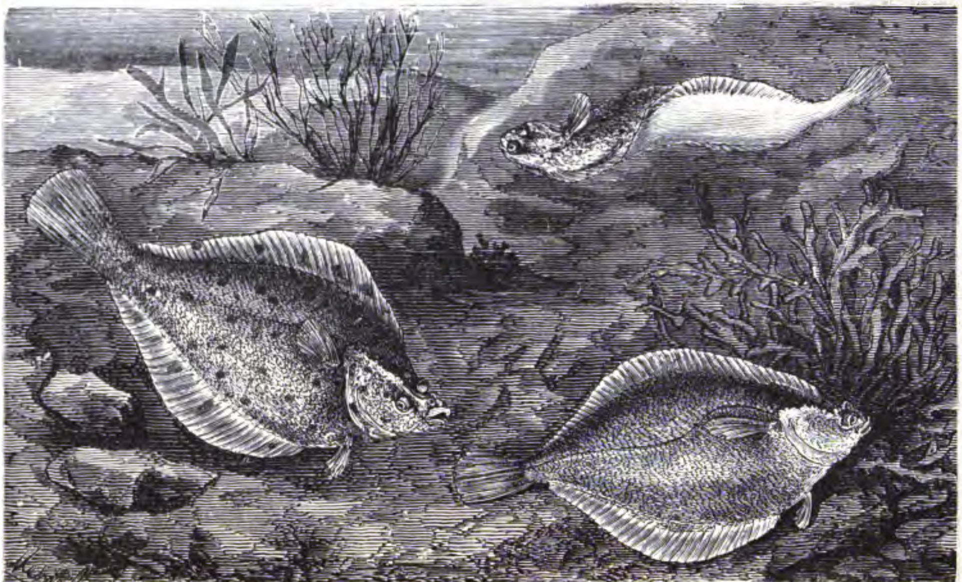
FACTS ABOUT FLAT-FISHES.

To most people a fish is simply a living mechanism designed for the conversion of the very miscellaneous nutriment contained in sea and river water into a highly-palatable form of human food. So long as the food product is satisfactory, few questions are asked as to the structure of the aquatic machine producing it, or of the varieties of pattern it exhibits.

The merest tyro in fish-eating knows how far apart turbot and skate are in flavour and other edible qualities, but he is seldom aware that they are equally far apart in structure; on the contrary, he generally classes them together as members of the same great flat-fish family. A better knowledge of the fish we eat, if it did not prove an aid to digestion, would, at least, provide food for profitable reflection; and there is no group the study of which is more likely to have this effect than that of the much-eaten but little understood family of flat-fishes.

All normally-formed fishes, like the cod, maintain themselves, whether swimming or at rest, in a vertical position—that is, with the back above and the ventral surface beneath. Such, however, is not the case with the Pleuronectids, or flat-fishes. Their bodies are so compressed laterally, and their pectoral fins, which correspond to our arms, are so small, that they cannot maintain themselves in the position of a coin standing on its edge. They have consequently fallen on their side—in some species it is the right, in others the left side—and in this position they remain, whether swimming or at rest. The right and left sides of an ordinary fish thus become the upper and under surfaces of a flat-fish; and in order to render this a tolerable arrangement for the creature, nature has wrought some strange modifications in its structure. The side which is uppermost shows a much greater development of muscle than that which is under, thus imitating the back of an ordinary fish. It is on the same side, also, that colour is developed; the opposite side, which in normal fishes always resembles the other, assuming in this case the ghastly white appearance ordinarily seen on the ventral surfaces of fishes.

The least observant person can hardly fail to notice a decided queerness in the eyes of flat-fishes. To be like other fish they ought to have an eye on each side of the head; but since they have practically converted one of their sides into a ventral



FLAT-FISHES: PLAICE AND DAB.

of the head. They then begin to lose their erect position, and with this change the eye on what afterwards becomes the blind side "travels," says the late Professor F. M. Balfour, "a little forward, and then gradually rotates over the dorsal side of the head, till finally it comes to lie on the same side as the other eye." During this journey the eye in most of these fishes remains at the surface, and continues functional—that is to say, is not closed during alterations.

There is at least one group of flat-fishes, however, in which the eye travels by a different route. Instead of keeping at the surface, it sinks, in those cases, into the tissues of the head, and gradually makes its way through to the other side. In these the travelling eye has for some time an opening on both sides, the creature appearing to have three eyes, until the opening on the blind side closes over. It is a curious fact, also, that as soon as the under side becomes blind, it loses its pigment cells and becomes colourless.

The colour of the upper surface usually so agrees with that of the sand or mud on which flat-fishes rest, as to render them scarcely distinguishable, unless when in motion; while many of them seem to have the chameleon-like power of changing their [illegible] t will, to suit the changing hues of their [illegible] lings. In fishes that have so departed from [illegible] al type, it is not surprising that individuals

of the same species should occasionally vary among themselves. Thus, a very common variety of the flounder is that in which the colour and the eyes are on the left instead of the right side. Specimens are also occasionally obtained with the colour on both sides, as in ordinary fishes, and others—albinos—in which both sides are colourless.

According to Günther, there are about two hundred different kinds of flat-fish known; and quite recently the Americans, by means of their splendidly equipped Fish Commission, discovered a new species, which, from its abundance on certain "banks" off the United States coast, is expected to prove a valuable addition to their food fishes. In this kind of fish the Americans are not so well supplied as the mother country, the turbot and the sole—the two choicest of our flat-fishes—being absent from their waters. The submarine valleys of the Atlantic are too deep to permit of those ground-fishes emigrating of their own accord to the New World.

The attempt, however, has lately been made to transport young turbot and soles alive across the Atlantic in salt-water tanks, with the result that only a single pair of soles survived the voyage. These were dropped into the sea within sight of Cape Cod, but it is scarcely probable that more will be heard of them. The experiment is not likely to succeed, until a consignment of the fertilized eggs of those fish can be sent across the Atlantic.

It is a fact, however, that the eggs of the turbot and the sole have never been observed under natural circumstances after their extrusion from the parent fish. The female sole with the roe ready for spawning may be readily obtained; but so experienced a pisciculturist as the late Frank Buckland stated, in one of his Fishery Reports, that he had never been able to find the milt of a sole.

Does the spawn of flat-fish sink to the bottom like that of the herring, or does it float on the surface like the spawn of the cod? This question is important, as bearing on the alleged damage done to the spawning grounds of sea-fish by trawling; and, so far as it can be answered, it goes to show that this much-maligned mode of fishing cannot injure the spawn of flat-fish. So far as the writer is aware, it is not yet known by direct observation whether the eggs of the sole, turbot, halibut, and flounder sink or swim; but Professor Sars and Dr. Malm independently discovered that the eggs of the plaice float on the surface during the hatching process.

The plaice, however, is one of the most typical of flat-fish, and the mode of spawning in it is almost certain to be that followed by all the rest. That they are as prolific as most other fishes is seen in the number of eggs contained in their roes, the number in the sole being reckoned at about one hundred and thirty-four thousand per pound weight

of the fish; while a turbot, the roe of which weighed five pounds nine ounces, contained no less than fourteen million, three hundred and eleven thousand, two hundred eggs.

Being among the most defenceless of fishes, this enormous reproductive power is no doubt necessary in order to maintain their numbers in face of the many enemies which prey upon them. Man is certainly not the most destructive of these, yet the consumption of soles in London alone is estimated at one hundred million, and of plaice at about half that number annually.

They in turn feed upon the still humbler denizens of the sea, their food consisting chiefly of worms, shell-fish, crustaceans, and to a slight extent of small fishes. In the case of the halibut, however, the latter, and these sometimes of considerable size, form the principal food. The halibut is the giant of the flat-fish family—one landed at Wick in 1877 having measured seven feet one inch in length, and weighed two hundred and thirty-one pounds; while another, caught by a Newbiggin fisherman, weighed two hundred and ninety-four pounds.

If the Americans have not turbot, they have halibut, and big ones too—one that was lately sold in the Boston market having weighed about four hundred pounds, while another caught off Portland weighed six hundred pounds. The turbot is the next largest of the tribe, thirty pounds being not an uncommon

weight, while examples weighing seventy and ninety pounds respectively have been recorded.

It also feeds to some extent on other fishes, and has the reputation of being exceeding voracious. It has thus been known to seize a gurnard attached to a hook, and to get choked in the attempt to swallow it. Occasionally it occurs in great abundance in the North Sea: thus it was reported lately that no fewer than two hundred and forty thousand turbot, weighing on an average more than one pound each, had been caught at Skagen, off the coast of Jütland.

Flat-fishes chiefly abound where the sea is shallow, and the bottom formed of sand or mud, as on the "banks" and in the estuaries of rivers.

Few marine fishes are more tolerant of brackish, and even of fresh water: thus the plaice, according to Yarrell, has in East Friesland been transferred from the sea to fresh-water ponds, and has thriven well. The flounder is also very partial to the brackish water of the mouths of rivers, and often makes its way for a considerable distance up-stream. Like the plaice it has also been found to thrive well when transferred from salt to fresh water, although it is said not to breed in the latter.

Several of our food-fishes are supposed to approach the coast in winter for the sake of the greater warmth of the shallow estuarine waters. The sole at least, among British species, pursues a

contrary course, retiring, as it does, if the winter be severe, into those deep depressions in the North Sea known as "pits," where they congregate in immense numbers. The "Outer Silver Pit," some miles east from Flamborough Head, is one of the most famous of these winter resorts of the sole. Here the trawl was first applied during the very severe winter of 1843, and in its deeper parts those fish were found in almost incredible numbers—an abundance which continued until the advent of milder weather enabled the soles to disperse. Severe winters have thus come to be known among English trawlers as "Pit Seasons."

Skate, although flat, are very far removed structurally from the true flat-fishes, or *Pleuronectidæ.* They are quite symmetrical, their flat disk-like forms being due, for the most part, to the great development of their pectoral fins; besides, skate have a cartilaginous skeleton, while that of flat-fishes is bony.

A rough idea of the affinities of the two groups may be obtained from the statement that turbot, soles, flounders, and plaice are practically unsymmetrical, compressed cod-fish, while skate are flattened dog-fishes or sharks.

XVIII.

THE HERRING AND COD FISHERIES.

THE herring takes its name from the German *heer*, a host; and the shoals of this favourite *clupea* at present (1880) visiting our north-eastern shores fully justify the title.

In answer to the question of the origin of those migratory hosts, naturalists used to point to the Arctic Circle as the home of the herring, whence it was supposed annually to migrate southward to spawn. Unfortunately for this theory, no one ever seems to have encountered such shoals descending from high latitudes, nor have Arctic voyagers succeeded in finding the herring "at home" in any numbers in Polar waters. This theory also failed to explain how it came about that the herrings of Loch Fyne differed in flavour from those of Wick, and how it happened that the dwarfs of the species invariably found their way into the Baltic. These and many other dark points were, however, explained by the theory now

held that the herring is a local fish, remaining all the year round in the vicinity of the coasts frequented by it during the spawning season, and having its migrations confined to the passage from deep to shallow water, and *vice versâ*, according as it is going to or returning from its breeding-grounds. If the fish of the west coast are, as a rule, better flavoured than those of the east, it is probably due to the greater abundance or superior quality of their food in the western lochs; while the stunted growth of the Baltic herring is now attributed to the gradually increasing deficiency of salt in the waters of that nearly land-locked sea.

Although thus a local fish, the herring, unfortunately, does not always keep to its recognized localities. It will suddenly disappear from places long frequented by it, and as unaccountably reappear after the lapse of years. A good instance of its uncertain habit in this respect was recently recorded by the British consul at Gothenburg, who stated, in a report to the Foreign Office, that the herring shoals which had suddenly disappeared from that neighbourhood in 1809, taking with them a flourishing industry, had reappeared at Christmas 1877, "when whales were seen following the shoals of herring to the coast." The Swedish fishermen, according to Bertram, attributed the disappearance of the herring to the frequent firing of the British ships at that time in the neighbourhood of Gothenburg.

That much more peaceful sounds might suffice to scare away the shoals would seem to have been the belief of the fishermen of St. Monance, who used, it is said, to take down the church bell during the fishing-season. Fishes are certainly not devoid of hearing power, and from recent investigations made by the Meteorological Society of Scotland, thunder-storms, whether from their accompanying noise or their electrical discharges does not appear, would seem to have a scaring effect on the herring; for although a good "take" may be expected on the day when such a storm prevails along our east coast, few or none need be looked for on the following day, unless on the confines of a deep part of the sea, to which the frightened fish would appear to be retreating.

While thus at times disappearing suddenly from particular localities, in other cases they take leave more gradually. Thus they do not enter the firths on the east of Scotland in such numbers as formerly; and this is notably the case with the Firth of Forth, where the summer fishing is now nearly abandoned. At Wick also herring have of late years been caught in much smaller numbers than formerly; while on the Aberdeen and Forfar coasts, and especially at Fraserburgh, the "take" has been enormously increased. The decrease in such cases has been attributed by some to overfishing. This, however, was not the opinion of the Commissioners who lately

took evidence on this and other questions connected with the herring-fishery, and who stated in their report that "nothing that man has yet done, and nothing that man is likely to do, has diminished, or is likely to diminish, the general supply of herring in the sea."

The number of herring taken by our fishermen is trifling compared with the multitudes which fall a prey to whales and seals, to the cod, the ling, and the dog-fish, and to gulls, solan geese, and other sea-birds. The annual "take" of herring on the Scottish coast is about a million barrels, or about eight hundred million herrings. The Commissioners already referred to, however, compute that the solan goose alone devours three hundred million herrings more than the total number taken by the Scottish fishermen; while, calculating from the number of cod, ling, and hake taken annually in Scottish waters, they estimate that these three fishes alone consume among them no fewer than twenty-nine billions of herrings—that, in short, man does not destroy one herring for fifty devoured by other animals.

The presence of large shoals of herring is, during summer, frequently indicated to the fishermen by the appearance of considerable numbers of sea-birds accompanying and preying upon the fish, and sometimes, although more rarely, of whales and porpoises. Hugh Miller tells of Cromarty Bay being on one occasion literally covered with herrings and birds,

while no fewer than seven whales, apparently of large size, were seen within the short space of half a mile.

The late Mr. Mitchell, in his excellent work on the "Herring," states, on the authority of two intelligent and trustworthy fishermen of Newhaven, that "the herrings take considerable flights out of the sea," and he suggests that in the cases noticed by those fishermen the herrings were probably being pursued by the fiercest of their foes, the dog-fish. This observation of the flying power of the herring, if trustworthy (and Mr. Mitchell evidently saw no reason for doubting it), may serve to throw some light on the occurrence narrated by a correspondent in the *Scotsman*, who states that recently he observed what is known as the "flying-fish" in Loch Fyne. Now, the latter might with sufficient accuracy be described as a herring with remarkably long pectoral fins, one of its names being the "flying-herring;" and as Loch Fyne is naturally suggestive of those fishes, it is possible that, unless near enough to mark the great length of the pectoral fins, the observer may have witnessed another instance of the leaping powers of *Clupea harengus.*

The writer had a somewhat similar experience nine years ago, when travelling by steamer to Aberdeen, in a sea uncomfortably rough. As the vessel steamed along the Forfarshire coast, his attention was arrested, and his *mal de mer* for the

moment forgotten, by the appearance of a herring-like fish progressing by a series of leaps out of the water. The storminess of the weather, and the imperfect light of daybreak, however, prevented any satisfactory observation of the creature's fins; but until reading Mr. Mitchell's statement of the aërial feats of the herring, the writer did not doubt that he had seen the so-called "flying-fish" off the east coast of Scotland.

The herring, as might be supposed from its numbers, is very prolific, the roe of a single female containing nearly forty thousand eggs. To deposit these, it seeks the shallow water of our coasts, and there the eggs attach themselves to whatever object they may chance to light upon. These are said to get hatched in two or three weeks after deposition, after which the young fish—known during its juvenility as "whitebait"—grows rapidly, attaining, according to Mayer, a length of two-thirds of an inch during the first month, and measuring nearly three inches long by the end of the fifth.

The importance of the herring-harvest is seen in the fact that, exclusive of the enormous quantity of these fish consumed in this country, the value of the herrings annually exported is about one million sterling.

The cod and the mackerel equally with the herring are more or less migratory in their habits; although their migrations never extend much beyond

the limit of the known resorts of the species. These movements are usually from deep to coast waters, and are undertaken partly for the purpose of spawning, and partly in order to obtain, at certain seasons, a more abundant supply of their favourite food. The comparatively full knowledge now possessed of the extent of their migrations is of the utmost importance, as it will enable those fisheries to be carried on at all seasons, although at different depths and with different fishing-gear.

Recent investigations have brought into special prominence the influence of temperature on the habits of these and other "commercial" fishes. Britain is supposed, and rightly so, to be greatly indebted to the Gulf Stream for much that renders life endurable, and believers in Macaulay's New Zealander are never tired of dilating on the awful fate awaiting us should the course of that beneficent flood be, by any freak of nature, diverted into another channel. We should be reduced, they say, to the forlorn condition of the half-frozen people of Labrador, whose country is no nearer boreal headquarters than our own. The people thus pityingly referred to not only have not the Gulf Stream to warm them, but they have in its place an Arctic current which insures for them a constant supply of the coldest glacial water; and yet it is almost certain that they, as well as the inhabitants generally of the Canadian shores, would have reason to regard

the substitution of the warm Gulf Stream for their present cold current as a calamity little inferior to that which would overtake Britain by a reversal of the process.

The reason for this lies in the fact that the existence of a practically inexhaustible supply of food fishes is due to the presence along the shores of the Dominion of an enormous area of cold water produced by those Arctic currents, and teeming with countless myriads of minute and even microscopic creatures—the usual inhabitants of glacial waters, which form directly or indirectly the great storehouse of food for the fishes of commerce. Within certain limits, however, there is considerable variety in the temperature of this area, not only on the surface, but also at different depths, due to various causes which need not be particularized. This *temperature stratification*, as it has been called, determines to a great extent the position of the zones of minute animal life, and therefore has an all-important bearing on the great fisheries.

The water on the fishing-*banks*, for example, is colder than that of the surrounding sea at similar depths. These places are on this account inhabited by many species of shell-fish, only occurring elsewhere in boreal regions; and as they form a favourite food of the cod, their presence has caused those *banks* to become principal places of resort for this species. The cod is undoubtedly the most important

member of the fish fauna of Canada, the average weight of the quantity caught annually in North American waters amounting to one hundred and eighty-five thousand tons, representing, it has been calculated, from one hundred and fifty to one hundred and seventy-five millions of fish.

Of these, only a small proportion is obtained from the one thousand miles of New England coast thrown open to the Dominion fishermen. The failure of the fishery in that once productive region which contains the now inappropriately named Cape Cod seems to be due to many causes. The effect of the Arctic current in lowering the temperature is here to a considerable extent neutralized by close promixity to the Gulf Stream. The small fishes, to prey on which attracted great numbers of cod to the coast, belong to species which ascend the rivers at certain periods of the year to spawn, but owing to the increasing pollution of the streams caused by the development of the New England manufactures, these fish have been gradually disappearing, and have taken their enemies with them. Above all, this portion of the United States coast has been fished in season and out of season, altogether beyond its capabilities, and with an utter disregard for its future productiveness.

A most improvident industry has also of late years assumed considerable proportions wherever the cod abounds—namely, the sale of cod roe, which

is largely used for bait, but which also forms, especially in France, an article of human food. To obtain this in sufficient quantity, the gravid female is caught, and the roe, which sometimes forms one-half of the entire bulk of the fish, is extracted. That the cod continues to abound anywhere under conditions which amount very nearly to the killing of the goose that lays the golden egg, is no doubt due to its remarkable prolificness, a single female depositing sometimes as many as eight million eggs. Were even a moderate proportion of these to attain to the dignity of adult fishes, the sea would soon, and that without using any hyperbole, be not large enough to contain them all.

The eggs are deposited in the water and float on the surface. A large number of them, however, never get fertilized; still more of them are devoured by fishes and other marine creatures, whose principal food, in many instances, they form; while of those which live to leave the egg only a few survive their earliest days. Recent researches tend to show that they do not usually reach maturity till their fourth year, and that the *shore* and *bank* cod, which many have supposed to be different varieties, if not even distinct species, are merely cod of different ages, the immature fish keeping as a rule near the shore, while the banks form the resort of the older fish.

XIX.

WHALES AND WHALE FISHING.

WHALES and whaling have, in the popular mind, come to be associated almost exclusively with Polar ice and Arctic voyaging. The truth is, however, that whales are found everywhere in the ocean; and that whaling is, or has been, pursued in almost every sea. The Basques were the first European whalers, and they pursued their hazardous calling in the seas around the French and Spanish coasts. For centuries those home waters were the resort of a whale closely allied to, but not identical with, the Greenland species, being somewhat smaller, more active in its movements, and more difficult to capture than the latter. Captured, however, it was, and in such numbers as effectually to extinguish the fishery two centuries ago. It seems to have come very near also extinguishing the species, for an individual of this Atlantic right whale, as it is called, is not now seen more than once in about ten years.

Traditions of this once flourishing fishery are still abundant in the Basque provinces; and Mr. Markham, who recently investigated the subject on the spot, found no fewer than six towns in the north of Spain which had the whale for their coat of arms, while he found in many of the fishermen's houses the harpoons which had been used by their hardy and enterprising ancestors. The harpoon itself, as well as its English name, are said to be of Basque origin; and Basque seamen taught its use to the first English whalers, it being customary in the early days of the Dutch and English whale fishery to take a boat's crew of Basques to harpoon the whales.

Whales of various kinds are not unknown in British waters, and at least one species is caught annually in considerable numbers. This is the ca'ing or pilot whale, which occurs frequently off the Orkney and Shetland coast in herds of two or three hundred individuals. When this happens, the entire fishing-fleet sets sail for the purpose of getting to seaward of the herd, endeavouring thereafter to drive the whales ashore. In this they are often successful, and as many as fifteen hundred and forty have been known to be killed in a couple of hours in a single Shetland bay.

This species also occurs much farther north, and is an object of pursuit by the regular whalers; thus, during the season (1882) just ended, the Dundee

whaling-fleet is said to have captured altogether one hundred and sixty-nine whales, of which no fewer than ninety-eight were "bottle-noses," as this species is also called. According to Captain Gray of the *Eclipse*, these small whales are much harder to kill, and when struck run out line much faster than even the big Greenland form. Their oil, however, is worth at present £60 a ton, or nearly double that of ordinary whale oil.

Although the Greenland right whale has hardly ever been known to stray so far south as the British coast, as large a species—the razor-back or rorqual—is a frequent visitant. It is a native of north temperate seas, and from a commercial point of view is altogether unprofitable. Its pursuit is more dangerous than that of the right whale, while when captured the thinness of its blubber and the shortness of its whalebone render it of little value. Besides, unlike the Greenland species, it feeds mainly on cod and other valuable food fishes, as many as eight hundred of the former having been taken from the stomach of a single individual. It frequently enters our seas in pursuit of the herring shoals, and will even follow these into bays and estuaries. Thus, Cromarty Bay has at times been seen to swarm with these whales. During the sprat season, according to Holdsworth, they are common in Donegal Bay, where they are dreaded by the fishermen, as accidents have hap-

pened from their coming up among the boats and capsizing them. They frequent in large numbers the eastern coast of the United States, and at Provincetown in Massachusetts the hunting of these razor-back whales or finners has lately become an important industry.

This is probably due to the safer and more expeditious method now adopted for killing them, —namely, by the use of the bomb-lance and gun. The former consists of a cylindrical iron tube about an inch in diameter and from one to two feet in length, filled with gunpowder, and provided with a fuse. The one end of the lance is sharp, while the other is feathered like an arrow, the "feathers" being formed of india-rubber, and serving to steady the bolt in its passage from the muzzle of the gun to the whale's body. The bomb-lance is fired into the whale generally behind the flipper, and its entrance is shortly afterwards followed by an explosion which usually causes the instantaneous death of the whale. These bomb-lances are gradually coming into use both in the Arctic and Antarctic fisheries, although more generally adopted by foreign than by British whalers.

This expeditious method of despatching leviathan may remind some of our readers of the ingenious expedient suggested by the late Sir R. Christison, of placing glass tubes containing prussic acid in the shaft of the harpoon in such a way as to have them

broken in the animal's body so soon as the harpoon line was tightened. This method was tried, as well as that of firing bullets similarly charged, and both were found entirely satisfactory, the whale after being shot disappearing for about five minutes, and then rising dead to the surface. Sentimental reasons on the part of the whalers themselves, however, prevented the adoption of this really humane method of killing the whale.

Another razor-back whale is that known as "Sibbald's," a specimen of which was stranded in 1879 at Longniddry; while the skeleton of another, seventy-nine feet long, is familiar to all visitors to the Edinburgh Museum of Science and Art. In this species the blubber is thicker than in the common razor-back; it therefore forms a more valuable prize. It appears to occur abundantly, according to Nordenskiöld, in the fjords on the coast of Finmark, where a flourishing fishery has been in existence since 1864. During the past summer (1882) the Norwegian fish ry in that region succeeded in capturing no fewer than three hundred and eighty-three whales. At one of the Finmark stations the method has lately been tried of two steamers hunting in company, the one shooting the whales and the other towing them to the station for flensing and preparing the oil; and apparently with satisfactory results.

The most widely distributed of the large ceta-

ceans is the sperm whale, which, instead of being an Arctic and Antarctic form, as was at one time supposed, is really a native of tropical and warm temperate latitudes. Occasionally, however, it strays both north and south of its usual limits, and many specimens have thus occurred on the British coast. One, for example, ran ashore more than a century ago in the Firth of Forth, while another was stranded on the Isle of Skye in 1871. The sperm fishery is, however, principally carried on in the southern hemisphere, and largely by American and Australian whalers.

The feature about the sperm whale is its enormous head, forming as it does half of the entire bulk of the creature; and this is also the part of most value to the whaler. The bulk of its head is due to the presence of huge cavities in the front part of the skull, which are filled with spermaceti. This is in a fluid state while the animal is alive, and for a short time after its death. When captured, an opening is made into this part of the skull, and the still fluid spermaceti is baled out in buckets. It solidifies on cooling, and when purified forms the spermaceti which, before the introduction of paraffine, was the great rival of wax in the manufacture of candles. From the sperm whale is also obtained the peculiar substance known as ambergris, which now commands a high price as a perfume.

Another whale fishery in temperate seas is that

of the species known as "humpback" and the "Bermuda whale." Probably this was the species lately observed passing the Bermudas in an immense school, estimated by an eye-witness as forming a procession two miles long. The "humpbacks" are mainly hunted by the American whalers, and large captures of them were recently made off the African coast.

The most important whale fisheries, however, are undoubtedly those carried on in the immediate neighbourhood of the ice of both Arctic and Antarctic seas. The Greenland or right whale of the North is represented by a closely allied species in the South. The latter is now hunted largely from Tasmanian, Australian, and New Zealand ports, while Britain and America are the countries chiefly engaged in the Greenland fishery.

The chief inducement to the vigorous prosecution of those fisheries is the great value now set upon the baleen or whalebone of those species. The sperm whale has a large number of stout ivory-like teeth in its lower jaw, but the right whale has no teeth, their place being taken by about three hundred and sixty plates of whalebone, the largest of which are sometimes fourteen feet in length. The mouth of a full-grown individual of the Greenland species has been known to yield between one and two tons of this material; and its importance is seen in the fact that while fourteen years ago whalebone

was worth about £40 per ton, at the present time it realizes £1,150 per ton. This enhanced price is due partly to the growing scarcity of the commodity, and partly to the increased demand for it in various industries. A comparatively small quantity is now used in the umbrella manufacture; but the saving in this respect must be more than counterbalanced by its extensive use as a material for stiffening silks.

The oil for which whales were formerly chiefly valued would now seem to be worth less in the aggregate than the whalebone. Thus, during the past whaling season (1882), the Dundee ships brought home six hundred and seventy-six tons of oil, valued at about £25,000, while their cargo of twenty-five tons of whalebone gave a total value of nearly £29,000.

The use of steam and of such improved weapons as the harpoon-gun and bomb-lance has enabled the whaler to venture into regions formerly closed to him, and to capture more speedily and at less risk to himself the objéct of his pursuit. In so succeeding, however, there cannot be a doubt that he is gradually doing for the Greenland whale what the Basques did centuries ago for the Atlantic form—namely, rendering it too scarce to be worth the trouble of hunting. The whale breeds slowly, having a single young one in the course of one or two years; and it reaches maturity slowly, although

this is probably counterbalanced by its reputed longevity.

There has long been a lurking hope that the yet unexplored circumpolar region may prove to be a great nursery of the Greenland whale. This view is not, however, shared in by those who have seen most of the highest latitudes. "I am satisfied," says Mr. Fielden—one of the naturalists to the recent Arctic expedition—"that no whale could inhabit at the present day the frozen sea to the north of Robeson Channel. To penetrate thither from the north water of Baffin's Bay would be a hazardous task for this great mammal; and in this opinion the experienced whaling quartermasters who accompanied our expedition coincided. We may dismiss from our minds the idea or hope that nearer to the Pole there may be haunts in the Polar sea suitable for the right whale."

XX.

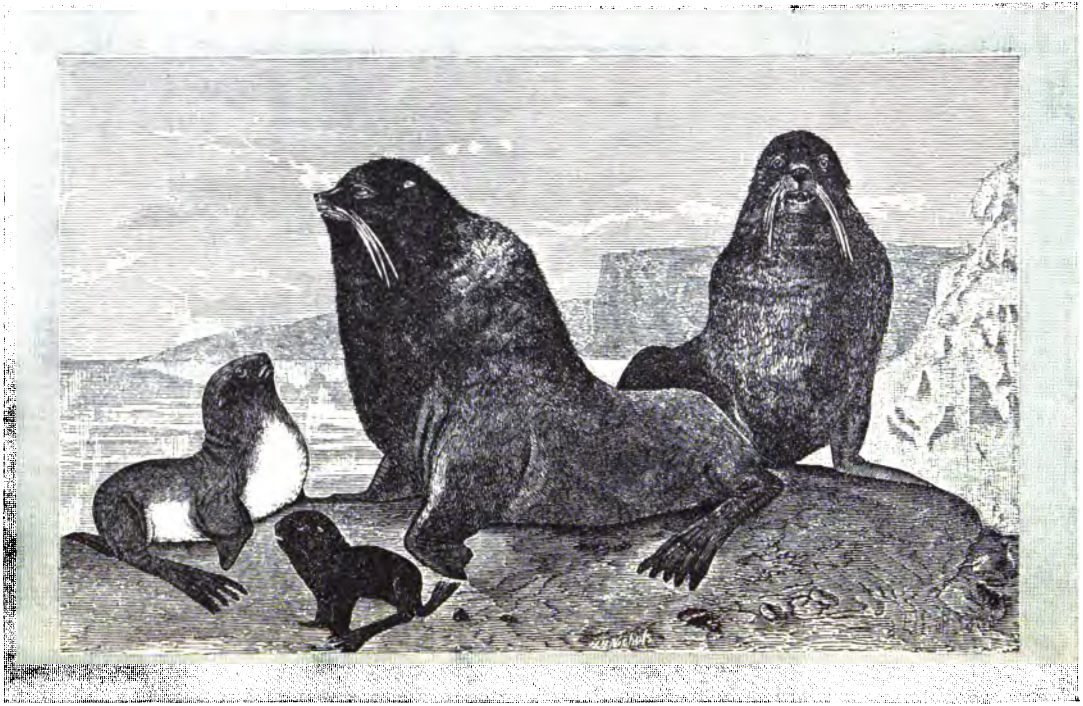
THE SEALS OF COMMERCE.

FUR SEALS.

Few animals so well known by their products are, popularly at least, so little known in their lives as the fur seals of commerce. It is not every seal whose coat is capable of being tortured by art into that combination of elegance and warmth known as sealskin. Of such skins imported into Great Britain annually to the number of nearly a million, more than three-fourths belong to the Greenland and other seals, hunted chiefly for their oil, and whose skins are only fit for making knapsacks and covering valises; while most of the remainder consist of the skins of the Northern fur seal, the species which almost exclusively supplies this valued form of winter clothing. It inhabits the seas in the neighbourhood of what used to be known as Russian America, but which, ten years ago, passed with its valuable seal-fisheries into the possession of the United States.

How far the Northern fur seal roams during the winter months, which it spends at sea, is not known; but in summer it seeks, for breeding purposes, the shores of a group of small islands—the so-called "Fur Seal Islands"—off the coast of Alaska, where from July till October it is to be found in incredible numbers. The chief of these islands is St. Paul's, which, although having only an area of thirty-three square miles, has a seal population in summer, estimated by Mr. Elliott, the United States Treasury agent, to exceed three millions. It is from this and the neighbouring island of St. George's that our supply of these valuable furs is almost wholly obtained.

The sole right to kill the fur seals on these islands is leased by the United States Government to the Alaska Commercial Company, which, in consideration of a royalty paid on every skin, is allowed to take one hundred thousand of these annually—ninety thousand from the island of St. Paul's, and ten thousand from St. George's. A government agent superintends the fishery—if the capture of seals on land can be so termed—and it is to the reports of those officials, the most interesting portions of which have been published in a marvellously complete monograph of *The North American Pinnipeds*, issued by the United States Government, that we owe most of our knowledge of the habits and mode of capture of those seals.



GROUP OF NORTHERN FUR SEALS

Early in May a few of the more powerful bull-seals make their appearance on the shores of St. Paul's—pioneers of the migratory host about to follow. These are bulky creatures, nearly eight feet in length, which, whether on sea or land, carry their heads high and their necks erect. Leaving the water, they select the most favourable positions along the shore, close by the water-line; and having once established themselves there, nothing but superior force can compel them to shift their quarters.

Their title to the best seats is, however, put severely to the test when, in the course of a month, the main army of adult males arrive, and begin to scramble for the best stations they can obtain. Fierce fighting becomes general, ending in the weaker members retiring to positions in the rear of the stronger. "I have marked," says Mr. Elliott, "one veteran who was among the first to take up his position, and that on the water-line, where at least fifty or sixty desperate battles were fought victoriously by him with nearly as many different seals that coveted his position." The scars and gashes, however, which covered his body and his gouged-out eye attested the costliness of his victory.

The serious question of precedence being settled by the rule of "might is right," there is no further fighting for places, partly because the *beachmasters*, as those breeding-bulls are called, do not vacate their hard-won posts so long as they remain on the

island, which is usually about three months. During the whole of this time they neither eat nor drink—a not unusual thing with such animals as bears during their period of hibernation, but probably unknown in the active life of any other creature. The bull-seals are, however, exceedingly fat on their arrival, and that they subsist on their own blubber is amply attested by their marvellously lean condition on leaving.

The young males, or *bachelors*, as they are called, have literally no *locus standi* among the beachmasters, and these are therefore fain to land beyond the boundary of the breeding-ground, or *rookery*, and to make their way as best they can to the rear of their more favoured elders, whence, as they have nothing particular to do, they make frequent excursions to the sea, where they are regarded as the champion swimmers of their kind. The cows are scarcely more than half the size of the bulls, and not a fourth of their weight—the strong contrast between the sexes in size and shape being further strengthened "by the air of exceeding peace and amiability" which the females exhibit.

These begin to arrive about the middle of June, and are immediately taken possession of by the beachmasters along the water-line, who deposit them in their respective lairs. One mate, however, is not enough for these "the most eminent of all polygamists in the brute world," who therefore set

themselves assiduously to secure more. In doing so their attention is temporarily withdrawn from their first conquests; and seeing in this their opportunity, the bulls of the row behind reach out their long necks and catch up the cows, just as cats do their kittens, and transfer them to their own seraglio grounds. These abductions apparently rouse the indignation, or, it may be, the cupidity, of the spectators in the rows immediately behind, and a general fight ensues, during which the females usually get moved still further back. In this way the cows, after much pulling about, get distributed among the various beachmasters,—those in front usually securing a harem of fifteen, although as many as forty-five have, in exceptional cases, been observed, while those on the stations behind have to be content with five or six.

In about a couple of days after the arrival of the cows the population is increased to the extent of about a million by the addition of as many baby seals as there are adult females; and after this event the parent seals remain on land only until their young are able to follow them in the water. This they cannot do, however, until they are about two months old, and during this interval the island is literally kept in a roar with the noise of its amphibious inhabitants. "The sound," says the writer already quoted, "arising from these great breeding-grounds of the fur seal, where thousands upon thousands of

angry, vigilant bulls are roaring, chuckling, piping, and multitudes of seal-mothers are calling in hollow, bla-ating tones to their young, which in turn respond incessantly, is simply indescribable. It is, at a slight distance, softened into a deep booming as of a cataract, and can be heard a long distance off at sea—under favourable circumstances as far as five or six miles—and frequently warns vessels that may be approaching the islands in thick, foggy weather of the positive though unseen proximity of land."

Strange to say, the young seals do not take to the water like ducks, and if put into it before they are six weeks old they drown as readily as any land animal; they have accordingly to be taught to swim. As soon, however, as their education in this respect is complete, young and old start off together on a sea voyage to their winter feeding-grounds, situate no one exactly knows where, but in journeying to and from which one-half at least of the infant seals fall a prey to the voracity of the killer-whale and other predatory animals.

Those fur seals which fall a prey to man—or rather to woman—are neither the members of the harem nor their polygamous lords, but the three-year-old bachelors—the age at which their fur is in finest condition. Not allowed by the beachmasters to occupy any part of the rookery, these herd together in vast numbers, often at a considerable

distance from the others, and can thus be readily captured without disturbing the quiet of the breeding-grounds. A few native Aleuts, getting between a herd of bachelors and the shore, effectually prevent their escape seawards, and they can then be driven inland as readily as a flock of sheep. Their organs of locomotion are, however, badly fitted for ordinary pedestrianism; they cannot, therefore, be driven at a greater speed than that of half a mile an hour without the loss of many lives.

They readily become overheated—a condition that proves speedily fatal, not to their lives only, which is of little importance to the Commercial Company, but to the value of their skins, through the loosening of the fur. The fur seals would appear to be peculiarly intolerant of heat, a temperature of a little over 40° F. being sufficient to set them fanning themselves with their hind flippers. Cool, moist weather, just foggy enough to obscure the sun, is what they specially delight in, and what they get during most of the Alaska summer. Rainy weather, on the other hand, makes them as uncomfortable as does the sunshine, and to avoid a shower they usually take a plunge into the sea.

On arriving at the killing-grounds, after a journey sometimes of three or four miles, the seals are herded until cool. They are then taken in squads of fifty to two hundred, and those of them that are found to be of suitable age—namely, three years—are

killed by blows upon the head with a heavy wooden club, while the others are allowed to make their way back to the sea. The work of skinning is then proceeded with, an expert performing this operation on a moderately-sized seal in a minute and a half. The skins are next removed to the salt-house, where they are laid one upon the other, "hair to fat," with abundance of salt between, and after lying thus for a week or two they are ready for shipment.

No one seeing the skin as worn by the fur seal would suppose it to be the original of the manufactured sealskin. The fine silky fur of the latter is in the living animal quite concealed beneath a coat of long coarse hair; and the removal of this hair, which must be pulled out, not broken, forms one of the most critical processes in the preparation of the fur. It requires both skill and care on the part of the workman; and through lack of one or other of these, large numbers of skins are annually spoiled. Those which pass this ordeal successfully, as well as the subsequent stages of shaving and dressing, are finally dyed the required colour, and the manufacturing process is complete.

Under the present arrangement with the Alaska Commercial Company there is no apparent diminution in the number of seals, while Mr. Elliott believes that other eighty thousand skins might be taken annually without endangering the future supply.

HAIR SEALS.

Besides the fur seals, whose dense coats of silky under fur supply the material for ladies' jackets, there are the hair seals, whose commercial value lies in the oil of their blubber and in their leather-making skin. The capture of these furless forms is the object of the seal fishery of this and other maritime countries; and its importance is seen in the fact that during the two or three months of spring which form the sealing season, a million at least of these pinnipeds, worth about £700,000, are taken.

Although all species are alike welcome to the sealer, the Greenland or harp seal, known also as the saddle-back, usually forms the bulk of his cargo, supplemented, however, by a number of harbour, rough, and hooded seals. A permanent resident nowhere, the Greenland seal has well-known breeding-places to which it repairs annually with the utmost regularity. These "breeding-grounds" are in reality great ice-floes, generally far removed from land, on which the young seals are born; and so rapidly do the latter grow that in three weeks they are said to be nearly half as large as their parents. They are also fattest then, and therefore most suitable for the purposes of the sealer. Although structurally adapted for an aquatic existence, the young Greenland seals, like the young of

the fur seal, do not at first take kindly to the water, entering it with reluctance, and requiring lessons from their parents in the art of swimming.

Their principal breeding-stations are the ice-floes to the east of Newfoundland, and those which surround the desolate island of Jan Mayen, the former being, however, the more important. Here they congregate in such vast herds that their cry, it is said, can be heard to the distance of several miles; nor is this surprising if, as Mr. Carroll in his "Seal and Herring Fisheries of Newfoundland" estimates, they number not fewer than from three to four millions. They are supposed to come from the Greenland coast, where they spend the autumn, and from which, availing themselves of the Arctic current, they migrate southwards as soon as the winter frost sets in.

As they keep close to the shore, their southward movement is eagerly watched for by the inhabitants of the Labrador coast, who do not fail to levy contributions on the passing host. At first they appear in small straggling companies, then in larger and more frequent bands, until at length the main army arrives. This alone, so vast are its numbers, takes about two days to pass, during which, according to a recent observer, "in all quarters, as far as the eye can carry, nothing is visible but seals—the sea seems paved with their heads."

Reaching the neighbourhood of Newfoundland by

the end of December, they bathe for a month in the warm waters of the Gulf Stream; then turning northward again, they encounter the ice-floes which form their "breeding-ground," and on which their young are born, usually by the first week of March.

They are said to spend altogether about one hundred and twenty days in the neighbourhood of the Newfoundland banks, and as their food consists almost entirely of cod and other white fish, the destruction of the staple fish of that region must be enormous. Mr. Carroll, allowing one cod daily to each seal—a very moderate allowance—calculates that the seals consume not less than three million hundredweight of those fish during their three months' stay.

The Newfoundland seal fishery has been regularly prosecuted for more than a century, but it may be said to have reached its maximum twenty-four years ago, when three hundred and seventy vessels and thirteen thousand six hundred men were engaged in it, and when the catch of seals was fully half a million. Since that time the number of ships and men employed has greatly decreased; but larger vessels, many of them steamships, are now engaged, with the result that the average take has not sensibly diminished. Thus, during a recent year, one hundred and seven vessels, one-fifth of them steamships, caught five hundred and twenty-six thousand seals.

The seal fishery, like marine harvests generally,

is, however, exceedingly uncertain, owing mainly to the unstable character of the ice-floes, which vary in their course with the prevalent winds and currents. The sealer may therefore never chance to hit upon the herds; or his ship may get fixed in the ice, and be thus detained till it is too late; or the still worse fate of being crushed in the pack-ice may overtake it.

The sealing-vessels usually arrive early in March, and cruise along the edge of the ice in search of their amphibious game. Having discovered the seals, the crew land on the ice, and each man, armed with a club and a hauling-rope, begins the slaughter, chiefly of the young. These make no attempt to escape, and are killed, or at least stunned, by a blow on the head, while their parents are, for the most part, away fishing for food in the surrounding waters. As the slaughter of the innocents proceeds, however, hundreds of the old seals, says an eyewitness, may be seen "popping up their heads in the small lakes of water and holes among the ice, anxiously looking for their young."

The parent seals cannot be so readily caught, for, although they are as unresisting as their young, they are more wary, and usually seek safety, when possible, by retreating into the water. For their capture, accordingly, recourse is frequently had to the rifle. When a seal-hunter has thus killed as many as he can conveniently drag to the ship, he pro-

ceeds to skin his victims, removing along with the skin the blubber which lies beneath it to the thickness of about three inches. The execution which can thus be effected in a single day by a ship's crew is enormous. "It is nothing uncommon," says Dr. R. Brown, "for a ship's crew to club or shoot in one day as many as from five hundred to eight hundred old seals, with two thousand young ones."

In their anxiety to secure as many skins as possible in the smallest possible time, seal-hunters have been blamed for the thoughtless barbarity of proceeding to skin the young seals before life in all cases is extinct. Such indecent haste, it is to be hoped, is now a thing of the past. Sometimes when seals are found in great abundance they are "bulked,"—that is, piles containing from five hundred to two thousand seals are raised on the ice at intervals of one or more miles, and flags are placed on them to enable the crew to find them again. Frequently, however, owing to sudden changes in the weather or drifting in the ice, these valuable piles are lost; still more is this the case when a ship, having secured, it may be, twice as many as she can carry, seeks the nearest port to discharge, and then returns to the ice for the remainder. Complaints have frequently been made by those interested in the seal fishery against the bulking system, as causing a wasteful destruction of seal life; and it is certain that no season passes without the loss of thousands of skins from this cause.

The ice-floes which collect in the seas about Jan Mayen and Spitzbergen form the next most important sealing-station. Here, at the breeding-season, according to Dr. Brown, the seals may be seen literally covering the frozen waste as far as the eye can reach with a telescope from the "crow's nest;" and here, until about the year 1870, the British, Norwegian, and German sealers annually killed two hundred thousand seals, Dundee alone in that year taking over ninety thousand. Since that time the Greenland fishery, as it is usually called, has greatly declined, owing mainly, it is believed, to the too early arrival of the sealing-fleet at the station. Seals were thus destroyed either before the birth of their young, or so soon after that the young, deprived of their parents, were unable to feed themselves, and so perished before they were old enough to be of any value to the sealers.

The continued failure of this Northern fishery, and the conviction that it was due to the above cause, led in 1875 to an international agreement on the part of the countries participating in it, by which the subjects of these nations are prohibited from killing or capturing any seal within a specified area under heavy penalty—in the case of a British subject £500 for each offence—before the 3rd of April. Such an agreement, if honourably carried out—and the sealers themselves have most to gain by its observance—would at least prevent the use-

less destruction of young seal life which formerly prevailed.

Next in importance to that of Jan Mayen comes the seal fishery of the Caspian Sea, where no fewer than one hundred and thirty thousand seals are annually captured. The seal found in this inland brackish-water lake is almost identical with one inhabiting the Sea of Aral and the fresh-water Lake Baikal, all of which bear a marked resemblance to a species found in Northern seas. This has been taken by A. R. Wallace as one of the proofs that a great part of Northern Asia was in comparatively recent geological times depressed beneath the level of the ocean, and that on its re-elevation the areas of depression marked by those inland seas retained part of the fauna of the Northern Ocean, with which they had till then been connected.

The Caspian seals congregate in large numbers on certain parts of the shore, where at night the sealers, landing, form a line so as to cut off their retreat seaward. "On a signal from the chief," says M. Schultz, who has specially studied the Caspian fauna, "the hunters all rise at once, and pitilessly attack their unfortunate victims, killing them by a single blow on the snout with their clubs. Their bodies are piled up by means of gaffs, and after a few minutes form a rampart, depriving the survivors of every chance of regaining the sea. The seals howl, groan, bite, and defend themselves; but the hunters,

eager for gain, go on killing them without mercy, and soon the whole herd is massacred. It is no infrequent occurrence to see fifteen thousand seals cover the battle-field of a single night."

Along the west coast of Greenland a seal fishery is carried on chiefly by the native Greenlanders and Eskimos, the annual catch amounting to about ninety thousand. To the Eskimo the seal is all-important, supplying him with food and clothing, light and heat, and many of his implements of the chase, while in exchange for the fifty thousand skins annually exported he obtains some of the products of more favoured lands. Seal's flesh is almost black in colour, but when the prejudice due to its appearance is got over, those who have tried it agree in praising its "flavour, tenderness, digestibility, and decidedly warming after-effects." It is evidently well suited for high latitudes—probably, however, requiring, as has been remarked of seal blubber, "an Arctic winter's appetite to find out how good it is."

XXI.

THE SPONGE FISHERY.

SPONGES of one kind or another abound in every sea. Few of them, however, have any commercial value. This is owing to the presence in them of lime or flint spicules, which, although forming beautiful objects under the microscope, are utterly fatal to that softness and elasticity which characterize the sponges of commerce. There are some, indeed, and these the most beautiful of their kind, in which the whole of what is usually regarded as the sponge is formed of glassy snow-white threads of flint. Thus, in the "Venus' Flower Basket" sponge—a tubular structure somewhat resembling the rose of a watering-pot—those delicate threads are so interlaced as to form a bit of basket-work, reminding one rather of a triumph of the glass-worker's art than any of Nature's products.

These "Flower Basket" sponges, when first brought into Europe, were of considerable marketable value, the first perfect specimen, now in the British Museum,

having been purchased in 1841 for £30; and twelve years ago they were still worth from £3 to £4. They have of late years, however, been found in such abundance as to have become almost a drug in the market. Mr. Moseley states that when the *Challenger* visited Cebu—the home of these sponges—they were brought off to the ship "in washing basketfuls," and sold at two shillings a dozen.

The sponge of commerce is free from all such gritty material, consisting solely of a delicate horny network, to which it owes its elasticity. It is found chiefly along the shores of the eastern part of the Mediterranean Sea, where, especially in the islands, its collection has long formed one of the leading industries.

Most of the recent information regarding this fishery has been obtained from the reports of the British consuls at the various ports where "sponging" is carried on, and from these it would appear that at the present time the sponge fishery is prosecuted after at least three different fashions.

Along the coast of Syria, where some of the best Turkey sponges are obtained, the fishery is carried on in the primitive style which has prevailed for centuries. A boat, manned by a crew of four or five—all, with one exception, divers—having reached the sponge-bed, usually not more than two or three ·s from the shore, the naked diver seeks the m, holding with both hands, that he may sink

the faster, a white stone to which a cord is attached. Once on the sea-floor he lays the stone at his feet, and holding by the rope with the one hand, he grasps and tears off the sponges with the other, placing them meanwhile in a net suspended from his neck. He then pulls the cord as a signal, and is drawn up, having remained beneath the water for a period varying from sixty to eighty seconds. There is good reason to believe that the latter figure is rarely if ever exceeded, although the divers themselves, who, it need scarcely be said, do not carry watches, tell marvellous tales of immersion for periods extending even to eight minutes.

A few fatal accidents occur every year, generally to the most daring and expert divers. To reach a specially tempting sponge, these will occasionally quit their hold of the rope; and should they miss it on returning, they run imminent risk of drowning in the attempt to reach the surface unassisted. Although sharks occur in those seas, fatal accidents from this cause are said to be rare, the rapidity of the diver's descent being supposed to scare away those dreaded monsters.

The art of diving has been so long practised in particular families that proficiency in it has become to some extent hereditary. In some of the Grecian islands the young fishermen were stimulated to excel in the diving art by the fact that they were not

allowed to wed until they had obtained a certain proficiency in it; while the maiden who had many suitors became the bride of him who could remain longest under the water and gather most sponges while there. The divers begin to lead their amphibious life at a very early age, and continue it up to about the age of forty. "I do not find, however," says the vice-consul at Beyrout, "that the practice has any tendency to lessen the span of life."

The Syrian sponge fisheries are said to employ about fifteen hundred men. These are not paid wages, but each member of the crew is entitled to an equal share of the produce, which in a good season is worth about £40.

Rhodes is the chief centre of the Mediterranean sponge trade, the annual value of the sponges exported being about £140,000. Here, as in most of the localities where the Greeks engage in this business, art has come to the help of nature, there being at present, it is stated, no fewer than three hundred diving apparatuses employed in the sponge fishery around the Turco-Grecian islands. This adoption of diving appliances by the Greeks—the Syrian divers eschewing them because of a prevalent belief that they bring on paralysis of the limbs—has led to a great increase in the quantity of sponges brought into the market, with the result that the sponge-beds are in danger of being ex-
ʰed through overfishing. In this, as in most

other fisheries, there is need of government control to the extent at least of enforcing a limitation to the size of the sponges sold. The Turkish authorities, however, are too eager for the golden egg which the tax on this fishery yields to think much of the killing of the goose; and probably it will last their time.

All the finer kinds known as Turkey or Smyrna sponges, including the beautiful bell-shaped toilet forms, come from this Greco-Turkish region. When brought up by the divers the sponge has a somewhat uninviting appearance, being covered throughout with a slimy gelatinous substance, consisting of the minute protoplasmic creatures whose skeleton or horny framework it is which constitutes the sponge of commerce. This glairy material runs freely from it, although to still further hasten its departure the sponge-gatherers usually trample their goods in holes dug in the sand.

Sponges are generally sold by weight, and formerly it was not uncommon for native dealers to add sand so as to increase their value. To defeat this fraud English merchants insisted upon all sponges being filled with as much sand as they would hold (ten pounds to a pound of sponge), and then deducting this known quantity of sand from the gross weight. This system is now, however, being abandoned in favour of that of buying the sponges by means of agents direct from the divers.

A coarser variety, known as "horse sponge," is obtained along the Barbary and Tunis coasts; and here a third method—that of dredging or harpooning—is employed, in applying which the Greeks far excel their Arab rivals.

The chief source of sponges, after the Mediterranean, is the Bahamas—a group of West India islands—where no fewer than ten varieties of commercial sponge occur, none of which, however, equals in quality the finer Turkish kinds. In a recently issued report of the Governor of the British colony of the Bahamas, much information is given regarding sponge fisheries generally. The export of sponges from these islands has of late years been steadily increasing, having increased in value from £24,700 in 1878 to upwards of £33,000 in 1879, and Governor Robinson is therefore afraid that the increasing demand may lead to exhaustion of the supply.

Having learned that the Austrian Government, under the advice of certain German professors, were attempting to propagate sponges artificially by cutting them in small pieces and sinking these in suitable localities, he sought information on the subject through the Colonial Secretary. This was obtained from Dr. Ray Lankester, and is given in an appendix to the report. From this it appears that the method, first suggested by Professor Oscar Schmidt, "of cutting a sponge into small pieces, of

affixing these pieces to movable supports, and sinking the supports in the waters where the sponges naturally occur, was found to be perfectly successful." The cuttings attached themselves to the supports, and gradually developed into sponges shaped like the blocks of which they were chips.

The attempt to artificially propagate sponges in the Adriatic was, however, abandoned, for two reasons. The fishermen, fearing injury to their occupation, "persistently disturbed and robbed the sponge-bed," and the cost of protecting it in the face of such hostility would, it was supposed, outbalance any probable gain. In the second place, although every cutting grew in the course of seven years into a sponge of marketable size, yet the weight of all those developed cuttings, it was found, would not exceed that of the undivided sponge had it been allowed to grow for a similar length of time. Now, a single large sponge is more valuable commercially than an equal weight of smaller sponges, so that a loss instead of a gain would result from the adoption of this divisive course.

The only advantage derivable from the practice of cutting living sponges would be that of spreading their growth into new localities. This, however, sponges can to a considerable extent do for themselves; for during an early stage of their lives they exist as free swimming germs, roaming about a while before settling down to their vegetative existence.

It is therefore probable that in the seas about the Bahamas all the ground suitable for the growth of sponges is already so occupied. There is little danger, however, of the exhaustion of existing sponge-beds in either hemisphere, provided care is taken that no sponges be sold of a size too small to be mature.

Of considerable value commercially, the sponge is of surpassing interest zoologically. That delicate horny structure—the toilet-sponge—is the work of apparently structureless bits of animated jelly, and the canals which run through it in every direction, and which show themselves on the surface as larger and smaller openings, are now known to serve important ends in the economy of its lowly inhabitants. Dr. Grant, after long-continued observations, discovered that there was a constant flow of water into the smaller openings or pores of the sponge, and that there was as regular an outflow of water from the larger apertures or oscula. He also found that the water from the oscula had, in its course through the sponge, been deprived of its oxygen and of its nutritious ingredients; while, on the other hand, it had become charged with the effete materials of digestion. It was thus shown that, by some means or other, water laden with nutritive matter was made to enter by the pores, and that passing along the canals it surrendered its valuable contents to the little protoplasmic animals arranged along the

sides; that sweeping on it gathered up the effete matter constantly being given off, until entering the wider passages its course got turned, when moving towards the surface it was at last ejected from the oscula.

The means by which these opposite currents are produced has been the subject of much controversy, but Dr. Grant has shown that in many cases at least they are produced by the action of vibratile cilia. These cilia are minute hair-like bodies found on certain parts of all animals, but occurring in greatest abundance among the lower forms of animal life. They are constantly in motion while the creature lives, and even continue to move for some time after life has become extinct. The cause of this motion is attributed to waves in the protoplasm to which the cilia are attached. Dr. Grant believes that such cilia exist in all sponges, though from their minuteness in certain species their presence has not yet been discovered.

A living sponge may thus be fitly described as a large and populous city, all honey-combed over with innumerable streets and lanes, and whose protoplasmic inhabitants ever sit, like Eastern shopkeepers, out of doors, and make their living by picking up whatever treasure fortune may put in their way. Nor are they totally unprovided with instruments for seizing their prey. In common with the Amœba, they have the power of sending out pro-

longations of their own substance, known as *pseudopodia,* or false feet; and casting these across the watery channel, they lie in wait for the unfortunate animalcule that has just been allured by the ever-waving cilia to enter in at the outside pore, heedless of the shattered remains of fellow animalcules that are being constantly ejected from the neighbouring osculum.

With regard to their mode of propagation, the parent sponge throws off little masses of protoplasm, which are taken up by the current passing along the canals, and sent out into the world of waters through the oscula. They float about in the water by means of cilia specially developed for this stage of their existence, and for some time show considerable activity. Their appetite at this season also appears to be enormous. On this point Mr. Carter of Bombay has furnished some interesting particulars. In one case "he saw one of these proteans approach a gelatinous body, something like a sluggish or dead one of its kind, and equal to itself in size, and having lengthened itself out so as to encircle it, send processes over and under it from both sides, which uniting with each other at last ended in a complete approximation of the opposite folds of the cell wall throughout their whole extent, and in the enclosure of the object within the duplicature. Even while the protean was thus spreading out its substance into a mere film to

surround so large an object, a tubular prolongation was sent out by it in another direction to seize and enclose in the same way a large germ which was lying near it. After having secured both objects, the protean pursued its course rather more slowly than before, but still shooting out its dentiform processes with much activity. It took about three-quarters of an hour to perform these two acts." Mr. Dallas, in his work on Natural History, also states, "that not unfrequently combats take place between two of these singular creatures, when, if the size of the combatants be nearly equal, they merely twist about for a short time and then separate, but if there be any great disparity in bulk, the larger one swallows up his antagonist without remorse." After leading this roaming life for a while, they gradually lose their cilia, settle down, and get attached to some object at the bottom, where they begin to build up their skeletons, and assume the form of sponges.

XXII.

THE PEARL FISHERY.

PEARLS have probably been known and appreciated by man from prehistoric times. Requiring no lapidary's art to reveal their beauty, they had only to be seen as they came perfect from Nature's laboratory in order to be prized.

That our rude ancestors could have altogether overlooked those animal gems is unlikely, seeing that shell-fish formed with them a staple article of food. Whether known thus early or not, mention is made of pearls in the earliest written records. They are spoken of in the book of Job, and in Chinese documents more than twenty-two centuries older than the Christian era they are stated to have been received as tribute and to have been given in dowry.

They occur, as every one knows, in the interior of certain shells, especially in that known as the pearl-oyster, although it would be more correct to call it a mussel; and various opinions have at

different times prevailed as to the mode of their formation. The ancients, with their fine imagination, regarded them as drops of rain or of dew swallowed by the mother-of-pearl and carried to the bottom of the sea. Modern science has replaced this fancy by a much more commonplace theory. Pearls, with all their delicate, silvery lustre, are but bits of carbonate of lime, like the rest of the shell, and their formation is due to the presence of minute parasites on the outside of the mantle of the pearl mollusk. These are a source of irritation to the creature, and in order to get rid of them "the pearl-oyster," says Gwyn Jeffreys, "smothers them with a coating of nacreous matter of the same description as that which lines the inside of the shell," the gradual superposition of layer upon layer of this material resulting in the formation of the much-coveted pearl.

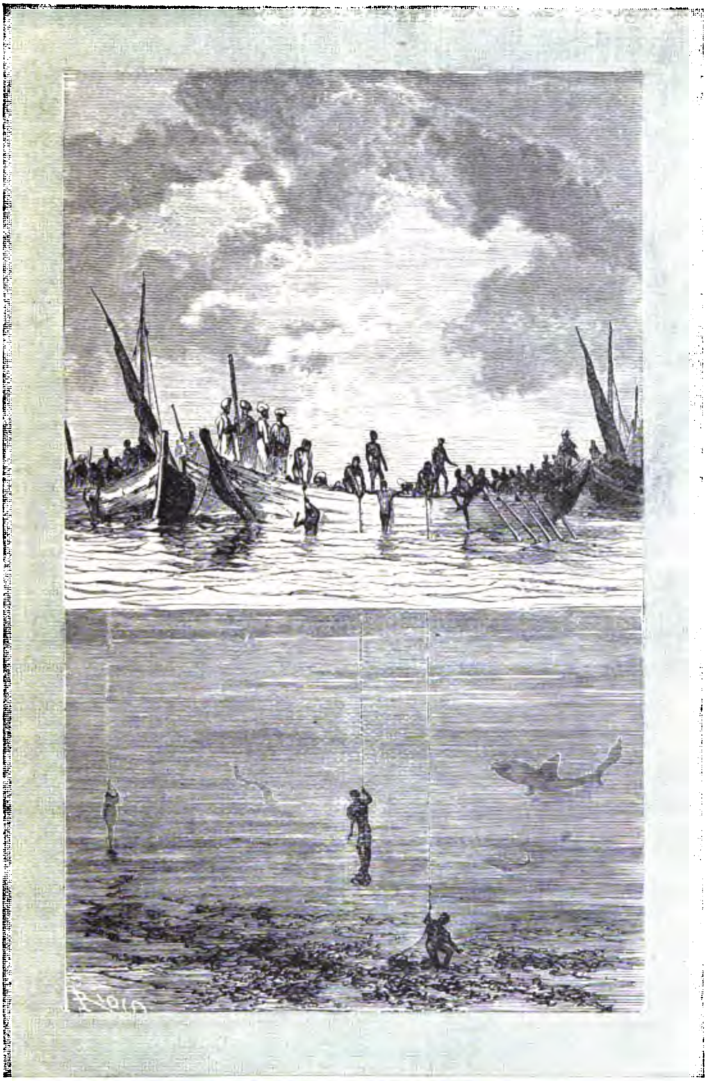
The most perfect of those ocean gems are found loose in the animal's body; others occur more or less attached to the nacre of the shell, and have to be cut out; while rarely they are found quite embedded in the matter of the shell itself. Some years ago a Birmingham workman in mother-of-pearl found a very fine pearl in this position of the shape and size of a small damson, which was eventually sold for £200.

The principal pearl fisheries are those of Ceylon and the Persian Gulf, although considerable quan-

tities are also obtained from the shores of Central America, known as "Panama Pearls," from the Malay Archipelago, and from the northern coasts of Australia. The Ceylon fishery is in the hands of the Colonial Government, who derive from it an exceedingly fluctuating revenue: thus in 1874 it only amounted to £7,200, while during the season (1881) which has just ended, and which has been one of the best on record, it is estimated to yield over £60,000. This fluctuation is due to the fact that for some reason not yet discovered the pearl mollusks forsake, sometimes for years together, their accustomed banks, going no one exactly knows where.

Unlike the oyster, which remains fixed for life, the pearl shell-fish moors itself to its bank by means of a bundle of threads called its *byssus;* and when for any reason it wishes to migrate, it has but to slip its natural cable in order to be free to seek fresh pastures. Although the natural history of these mollusks is by no means fully ascertained, it is generally understood that they take seven years to attain maturity as pearl-producers, and that the gems, if not secured then, are liable to deteriorate, while if taken from shells less than four years old they are of no value at all.

At the commencement of the fishery season, which occurs in the early part of the year, the usually desolate north-west coast of Ceylon becomes



PEARL FISHING, CEYLON.

for several weeks a scene of the greatest activity. Nearly two hundred boats, each with a crew of about twenty, sail for the bank, usually a few miles from the shore, which the Government inspector has indicated as ripe for fishing. Ten of the boatmen are divers, and five of these go down into the sea at a time. They usually work at a depth of six to twelve fathoms, to reach which as rapidly as possible they make use of a stone weighing about thirty pounds as a "sinker." Having reached the bottom, they place the gathered shells in a net-work basket taken down with them, which, on a given signal, is drawn up, the diver aiding his own ascent by springing on the rope as it rises. All this is the work of a single minute, few of the divers, indeed, remaining more than fifty-five seconds under the water, although the more expert of them have been known to stay below for eighty-seven seconds. The one set of divers enjoy a breathing time while the others are engaged at the bottom, but each diver is said to make from forty to fifty descents a day, bringing up each time on an average one hundred shells. During a recent season, extending only over forty fishing days, about seventeen millions of these are said to have been landed; and as the empty shells are all left on the shore—those from Ceylon being unmarketable as mother-of-pearl—they now form immense accumulations.

The danger most dreaded by the divers is that

arising from the attack of the ground-sharks abounding in those seas; but, strange to say, accidents from this cause are exceedingly rare. It is probable that the sharks are themselves alarmed by the noise of the boatmen, the frequent splashing of the divers, and the general commotion attending the fishery, and so give the pearl-seekers a wide berth. The latter, however, attribute their safety to the exorcisms of the shark-charmer, without the benefit of whose mystic incantations no diver would think of committing himself to the water.

On the return of the boats to the coast, the shells are divided in certain proportions between the Government and the fishermen, the former disposing of their share to the dealers. The shells are placed by their owners in pits, where they remain exposed to tropical heat until their soft parts are more or less decomposed, when the search for pearls begins—the workmen engaged in this responsible duty not being allowed, it is said, under penalty of a flogging, to lift their hands to their mouths.

A still more important pearl fishery is that carried on in the Persian Gulf, where the pearl banks extend for three hundred miles in a direct line, and where, although the fishery has been in existence from time immemorial, the yield of those shell-jewels, as the Japanese call them, shows no sign of exhaustion. No fewer than five thousand boats

and thirty thousand persons find employment in this fishery in the Persian Gulf, the annual-value of the pearls obtained being estimated at half-a-million sterling. They are usually of larger size than those found in the waters of Ceylon, but they are considered inferior to the latter in shape and purity.

Pearls are of various sizes, shapes, and quality; the largest ever found being about the size of a hen's egg, while great quantities not bigger than small shot are also taken. Those diminutive gems, known in commerce as "seed pearls," are generally ground to powder, and used either in betel-chewing or for medicine, a use to which it is largely put in China. The finest pearls are as a rule perfectly round, and generally of a white or yellow colour, although they occur of almost every imaginable hue; the New World products known as "Panama pearls" being brownish and pear-shaped, while those known as "Scotch pearls" are frequently rose-tinted. The latter, however, are obtained from a totally different mollusk—the *Unio margaritifera*, a fresh-water shell occurring in many of the mountain streams of Europe.

In the middle ages Scotland was famous for its pearls, and it is little more than a century since pearls to the value of £10,000 were sent to London which had been obtained from the rivers Tay and Islay in the course of three years. Over-fishing, it may be presumed, ruined the pearl fishery at that

time, as nothing more was heard of it till about twenty years ago, when it was revived through the exertions of an Edinburgh jeweller, and prosecuted with such success that in 1864 the pearl-seekers were believed to have realized £10,000 by their sale. The mania for pearl gathering which then prevailed soon exhausted the supply of a shell-fish at no time very abundant, and consequently little has been heard of late years regarding systematic pearl fishing in Scotland.

The rivers most productive of those gems were the Forth, Teith, Tay, Earn, and Doon, and the lochs connected with them; and could the over-fishing of these be prevented, there is reason to believe that they would yield a regular, if moderate, supply of pearls. Nothing, however, so far as the writer knows, has been done either to prevent the over-fishing of the natural beds, or to test the feasibility of a system of artificial culture such as is practised with regard to mussels in the Bay of Aiguillon. With regard to the chances of obtaining pearls in those river mollusks, one is said to be found on an average in every thirteen shells, but of these only one pearl in ten has any commercial value. That one, however, may be worth a considerable sum, as much as £100 having been paid for a fine Scottish pearl.

An allied species found in Chinese rivers helps to supply the great demand for these animal gems

which seems to have existed from very remote times among the Celestials. While Western naturalists, following Pliny's lead, were talking nonsense regarding the origin of pearls, the Chinese had already perceived that they were due to irritation of the molluscan body, and with an ingenuity worthy of the largest-brained race of men, they hit upon a plan of artificial production. Raising the shells from the river beds, they placed within them little metallic images of Buddha, &c., thereafter replacing them in the water. When a suitable interval had elapsed, these were fished up again, and the images, now coated with pearl, removed.

Gems of all kinds are now imitated with a fidelity that renders detection by the eye practically impossible, and this is fully as applicable to the pearl as to any of the purely mineral gems. Artificial pearls are hollow glass beads, which owe their pearly lustre to the application of a substance called by the French beadmaker who first used it *essence of pearl*, but which in reality consists of the scales of a small fish—the bleak. To produce a pound weight of scales, no fewer than four thousand of those fishes are required, and that quantity of scales only yields four ounces of the pearly material. The latter, mixed with isinglass, is blown into the hollow bead, the inner surface of which becomes varnished over with it, and this, when dry, is filled with white wax to give it weight. After being bored with a

needle and threaded on a string the spurious pearl is ready for sale. Those imitations are chiefly made in Paris, Nuremberg, Venice, and Bohemia; and their use has, it is said, considerably depreciated the value of the natural production.

XXIII.

PRECIOUS CORAL.

EXCEPTING pearls, precious coral forms the rarest, costliest, and prettiest product of the ocean-harvest. Its value as an ornamental stone was appreciated centuries before its true nature was known. Referred, in the first instance, to the mineral kingdom, it afterwards became universally recognized as a marine plant, the coral beads brought into Greece by her early navigators being regarded as the berries which had reddened and hardened on exposure to the air.

The discovery, centuries later, by an Italian naturalist, of the supposed flowers of *Corallium rubrum* was considered by men of science as conclusive of the correctness of the popular belief. When, therefore, a surgeon of Marseilles, a little more than a hundred years ago, found that the so-called flowers were in reality animals endowed with the power of voluntary motion, and when he communicated the fact to the French Academy of

Sciences, that learned body, in order to protect the author from inevitable derision, thought it prudent, in publishing his research, to conceal his name.

The surgeon, however, was right—corals, whether precious or otherwise, being nothing more than sea-anemones that have secreted a calcareous skeleton, and have become compound by budding. In a living state, the branching shrub-like coral of commerce is covered with a continuous leathery coating of a bright red colour, studded with minute openings out of which the milk-white polyps with their eight tentacles protrude, looking, for all the world, like flowers, and forming exceedingly beautiful submarine objects. It is these colonies of soft-bodied zoophytes which secrete the lime of which this valuable stone is composed.

Although coral is one of the most abundant substances in nature, entire islands and enormous reefs in tropical seas being wholly composed of it, the particular variety known as red coral, which is the only one having any commercial value, is comparatively rare, and is almost entirely confined to the Mediterranean Sea. It there occurs in reefs, generally a few miles from the shore, and at depths varying from a few fathoms to over a hundred.

The chief coral fisheries are those off the coasts of Naples, Sicily, Sardinia, and Algeria. Highly productive beds were formerly worked off Torre del Greco, near Naples, the consequence being that

nearly all the inhabitants of the place were engaged either in the fishery itself or in the manufacture of coral ornaments on shore. Those beds are now all but exhausted, and the fishermen pursue their calling chiefly on the coasts of Sicily and Algeria. They return with their precious freight, however, to Torre del Greco, which still continues the chief centre of the coral trade, although Leghorn, Genoa, and Marseilles are also important seats of the manufacture.

Few years pass without the discovery on some part of the Italian coast of a new bed of this valuable material, causing a rush to the spot and a rapid exhaustion of the coral. Such ugly rushes, requiring sometimes the despatch of an Italian man-of-war to keep order among the fishing fleet, will probably be less frequent in future, owing to the new fisheries law, which secures to the discoverer of a coral bank the exclusive right to fish upon it for two years. The occasional richness of those submarine "finds" may be gathered from the fact that six hundred boats, which were sent to a newly discovered reef off the coast of Sicily in the year 1880, took from it, in the course of a few months, not less than eight thousand tons of coral, valued at several million pounds sterling.

The fishery off the North African coast is under the control of the French Government, and foreign craft have to pay heavy dues for the right of

fishing;—in spite of which, however, the boats and their crews chiefly hail from Torre del Greco. To prevent the exhaustion of this important French fishery, the reefs are divided into ten portions, ten years being the time which the coral is supposed to take in order to reach its full growth; and as only one of these divisions is allowed to be fished annually, provision is thus made for an uninterrupted coral-harvest. The larger vessels engaged in this pursuit are usually about fourteen tons, and employ a dozen hands; the smaller being from three to four tons, with a crew of five or six. They are said to work night and day, half of the crew relieving the other half every six hours; and to continue at the fishing from March till October, faring during this time chiefly on macaroni and biscuit. As the result of their labours, the large boats usually succeed in fishing up from six hundred and fifty to eight hundred and fifty pounds of coral, and the smaller craft from three hundred and fifty to five hundred pounds.

The coral is usually found attached to rocks, being, according to Professor Giglioli, never found in mud or in muddy waters, but growing mostly on a regular coral rock formed of different species of madrepores. In some places, however, it is found attached to shells and other marine objects. It gives out branches in all directions, and attains a height of about one foot, with a thickness usually of less than an inch.

CORAL FISHING.

The apparatus employed in fishing for coral is exceedingly primitive, and only moderately effective. A frame, consisting of two bars of wood or iron, about fifteen feet in length, placed one across the other, and weighted in the middle with a large stone, is hung with abundant tangles of hemp, and with nets, one of which is usually attached to each of the four extremities of this cross-like dredge. This is let down, by means of a thick rope, on the submarine coral-bed, and is dragged backward and forward until the branches of coral are fairly entangled in the tow and netting. The rope is then attached to a windlass, and the dredge—not without much labour—is brought to the surface.

Precious coral varies considerably in colour, from a deep crimson red to a delicate rose pink. It is also occasionally found marbled white and red, while both black and white varieties occur. The deep red variety was formerly most esteemed in Europe; now, however, the delicate pink, especially if the colour be uniform throughout, is more highly valued. The finest pink coral is said to be worth from £80 to £120 per ounce, while ordinary red coral in small pieces is worth only £2 per ounce, and the fragments used for children's necklaces only 5s. The value of precious coral, however, depends largely on size as well as colour, and pieces of unusual thickness bring high prices, even when of a bad colour.

Coral has been employed from very early times as an ornamental stone. The ancient Gauls adorned their weapons of war with it, coral and amber being their only jewels. The Romans believed it to possess mysterious virtues, and used to hang branches of it round their children's necks to protect them from all sorts of danger;—a superstition not yet extinct in Southern Italy, where coral amulets are still worn to protect the wearer from the evil eye. "In jewels of the middle ages," says King, "coral beads are often to be found set in the same manner as the most precious gems." The taste for coral has since declined in Europe, and the bulk of this Mediterranean product has for centuries been exported to the East, chiefly to Persia, India, and China. In India it is in as much request at the present day as formerly Indian pearls were in Rome. The Hindus wear it in their turbans, and adorn the handles of their swords and daggers with it; the rosaries of their priests are made of coral beads; and they place it on the bodies of their dead in order to protect them from the inroads of evil spirits. The deep-red variety of coral, probably because it harmonizes better than the lighter kinds with their olive skin, is preferred by Orientals; and there is also a great demand in India for worm-eaten coral,—a variety regarded as worthless in Europe. It is not matter of surprise that, with this regular Oriental demand, Tavernier, the jeweller who travelled in

India two centuries ago, should have found that coral was the most profitable article that could be taken out to that country.

In China and Japan there is a steady demand for large spheres of good coloured coral, these being in request as buttons of office for mandarins' caps; and on this account coral balls weighing an ounce are said to command in those countries a higher price than any other precious stone. In one of the Italian exhibits of coral at the Edinburgh Fisheries Exhibition, one of those spheres, apparently about two inches in diameter, and of a pale red colour, was to be seen. Coral is also a favourite ornamental stone among the tribes of Central Asia, and with the negroes of Central Africa and America.

What is known as Japanese coral, and which seems to differ from the Mediterranean form chiefly in the much greater size to which it grôws, has been lately introduced into the market. A piece said to have been lately dredged in Japanese waters was stated to have measured fifteen inches in diameter and five feet in length. The *Challenger* expedition found no traces of this species in their dredgings off the Japanese coast, nor did any of the staff ever hear of its occurrence from the Japanese themselves. Professor Moseley is therefore inclined to doubt whether this gigantic form of precious coral is really an inhabitant of the waters from which it is alleged to have been taken.

Although the coral of commerce is thus for the most part obtained from the Mediterranean, it is not altogether confined to that inland sea. The *Challenger* expedition found a coral fishery in full operation off the coast of one of the Cape Verd Islands, employing seven or eight boats and one hundred men constantly. A rich coral reef has also lately been discovered between the Bermuda Islands and Nova Scotia, for which the fishers of Torre del Greco were said to be fitting out vessels much larger than any they had hitherto employed. There is no means of ascertaining accurately the value of the coral fisheries; but a few years ago the Algerian fishery alone employed three hundred and eleven vessels, manned by three thousand one hundred and fifty men, and yielded raw coral valued at £113,000. The yield of the Sicilian fishery, in which during last year (1881) no fewer than eight hundred boats were engaged, must have been considerably larger.

XXIV.

OYSTER CULTURE.

OYSTERS to the value of about six million sterling are said to be consumed annually in Great Britain. This sum, however, is to be taken rather as the index of a demand not to be checked by considerations of price than as a measure of the abundance of the supply, for certainly at no former period did so much money buy so few oysters. The natural *scalps* of Britain, which have supplied its inhabitants with oysters since the days of the old Stone folk, who, to judge from the vast piles of those shells found in their refuse heaps, seem to have lived largely upon them, have of late years, thanks to over-fishing, given evident tokens of exhaustion.

That this commodity has not almost disappeared from our markets is largely due to the oyster culture which now prevails both in this country and on the Continent, most of the English supply being obtained from the oyster-beds of private companies. In this country oyster-farming takes the form of

feeding rather than of breeding, the infant bivalves, known as *spat,* or the juveniles, known as *brood,* being bought wherever they can be got and placed on fattening grounds, which are kept as clear as possible from weeds, mussels, whelks, and other enemies of the oyster. Here the "natives," as those semi-cultivated forms are called, lie till, at the age of four years, they are considered ripe for the market.

The most ancient of these companies is that of Whitstable, on the estuary of the Thames, which has been known to pay £28,000 in a single year for the supply of brood. Could a sufficient supply of spat be obtained, there would be no difficulty in rearing any number of the finest oysters. For many years past, however, there has been a marked failure in the supply of this prime necessity of oyster culture.

Like others of its kind, the oyster is remarkably prolific, the eggs of a single individual being estimated at about a million. These are hatched before leaving the parent shell, entering the water as free swimming embryos. They soon, however, seek to fix themselves for life; but if a suitable anchorage does not come in their way they perish. Cold also kills great numbers of them, while still more are devoured by other sea creatures. It is believed, however, by many that the failure of spat in Britain of late years has been largely due to a

deficiency of spatting oysters. The natural scalps have been denuded not only of adult oysters capable of reproduction, but also of the young, for the supply of the Thames and other oyster farms. Did the latter spawn on the grounds to which they are transplanted, the evil would soon cure itself; spat would become plentiful at Whitstable and other beds, and it would be no longer necessary to rob the natural oyster banks of their precious brood.

The fact, however, that such replenishing is constantly necessary shows that the oysters, either because they are sent to market before they have had an opportunity of perpetuating themselves, or because the conditions are unsuitable, do not usually spawn at all. There have been, indeed, exceptional years when large quantities of spat have fallen on these cultivated grounds; but these are usually separated by long intervals. The presence of oysters in greater or less abundance everywhere on the British coasts proves the suitability of our seas for their growth and propagation. The failure of spat year after year may therefore be fairly regarded as due somehow to man's interference, and so admitting of remedy by more enlightened treatment. It is yet to be seen whether the recent Act enjoining a close time for oysters will prove sufficient for this purpose.

The French oyster fisheries were, thirty years ago, in much the same state of exhaustion as those of

the United Kingdom now are. The subject of oyster culture was then taken up in earnest; stringent regulations were made and enforced regarding a close time for the fishery, and a system of oyster culture was devised and taught, which has now restored to this marine industry its former prosperity with more than its former stability; for care is now taken that a sufficient supply of mature oysters is left for breeding purposes. In 1878 six hundred and forty million of oysters were sold in France, three-fourths of which were obtained from the oyster farms now established on almost every suitable point of the French coast, the remainder being dredged from the natural scalps, which are again becoming productive.

Four years ago (1879) there were no fewer than thirty-seven thousand such establishments in France, most of them, however, being engaged in fattening and preparing for the market oysters bred elsewhere. There are several very large breeding establishments, such as that at Arcachon, where an abundant supply of brood can always be obtained. Arcachon is a great circular lagoon communicating with the Bay of Biscay by a narrow opening, and covering an area of twenty-five thousand acres. It was formerly a productive oyster scalp, but was exhausted through over-dredging. It is divided into thirty-three hundred separate parks, held by about as many different people, who cultivate their little

plots of sea-bottom with as much assiduity as they do their vineyards.

For the reception of the spat as it falls they lay down tiles, to which the embryo bivalves attach themselves in such numbers that each of these has an average of from two hundred and fifty to three hundred on it. On this marine estate of Arcachon there are no fewer than six millions of these tiles, and these, it was estimated, yielded in 1877 no fewer than two hundred millions of infant oysters. During October the tiles are raised, and the young stripped off and put into pits for the winter; while in spring they are sorted according to their sizes, and placed in other pits less thickly than before, from which, after two years, they are ready for removal to the fattening establishments. The latter are generally more exposed to the sea than the breeding farms, a strong sea current being considered favourable to the growth of the two-year-old oyster; and as a mixture of fresh with salt water is found to bring the oysters still more rapidly into marketable condition, a part of the coast abounding in fresh-water streams is invariably chosen for these farms.

Another stage in the artificial culture of the oyster is that of imparting to them the green tint so highly prized by the oyster-eaters of Paris. The colouring is chiefly effected at Marennes, on the banks of the river Seudre, and is due to the absorp-

tion by the oyster of a green diatomaceous plant which abounds in the waters there. The oyster is sent alive from these farms to all parts of France, and is even exported alive to this country. Before it is able, however, to bear a lengthened journey without deterioration, the oyster has to be trained to keep its shell tightly shut when out of the water, so as to prevent the escape of its natural juices. With a view to this, those about to be sent long journeys in barrels are raked daily out of their muddy bed and left exposed to the air for a gradually increasing time. The discomfort which follows the opening of their shells in any but a watery medium soon impresses itself so upon the molluscan intellect that they quickly learn to keep themselves and their juices indoors so long as there is only air without.

The increasing productiveness of the Arcachon beds is shown by the export of oysters—none of them less than five centimètres across—which increased from forty-two millions in 1873 to one hundred and ninety-six millions in 1876, four and a half millions of the latter having been shipped to England.

The fact that the French have thus succeeded in establishing everywhere along their coast a valuable industry suggests the possibility of similarly utilizing the foreshores of the United Kingdom. The oyster is as much a native of our seas as it is of French waters; it is difficult, therefore, to under-

stand how the same attention to the details of oyster culture here should not have an equally successful result. The experiment has, however, been tried in Ireland, and has failed; but it is extremely doubtful whether, in this instance, the French system had a fair trial. The Arcachon beds were not an assured success until five years after they were started; and probably, had the Irish persevered like their Celtic neighbours, their efforts might have in the end been similarly rewarded.

Except in the Firth of Forth there are no oyster beds of importance in Scotland. The numerous sheltered bays and lochs of the west coast have, however, been often pointed to as eminently suited for oyster culture; and recently an attempt has been made to establish, on the southern side of Loch Creran, an oyster farm, somewhat after the French system, by Mr. A. Smith of Ledaig, who gives the details of his experiment in the volume of the Highland and Agricultural Society's Proceedings for 1881. Mr. Smith collected oysters from the surrounding coast, which he placed in wattled enclosures at the very lowest ebb-tide, and he seems to have spared no pains in order to insure abundant settling-places for the newly-hatched oysters. All his endeavours, however, were in vain, as neither in 1879 nor in the following year was any spat found deposited either on the wattles, on the gravel at the bottom, or on the parent oysters themselves. He is not inclined to

accept this as conclusive of the unsuitability of our western lochs for oyster culture, as the failure of spat, from whatever cause, was almost universal throughout the United Kingdom during these two seasons. He inclines, however, to the opinion—and there is much to be said for it—that beds in deeper water, with plentiful spat collectors suspended over and around them, would have greater chance of success, as our oysters seem to breed more freely in such water, while the foreshore could be utilized for fattening and preparing the brood for the market.

The United States is the greatest oyster-growing and oyster-consuming country in the world; and lately the Americans have begun to supply Britain with considerable quantities of those mollusks; no fewer than ninety thousand barrels of oysters having been imported into this country from America during 1879. They can be readily brought across the Atlantic alive, and Mr. Smith, with a view to their acclimatization in Britain, had a quantity of brood imported. These were placed in the Highland loch, when their introducer had the satisfaction of seeing them grow and fatten as if they had been true natives.

XXV.

SILK CULTURE.

ALTHOUGH there are upwards of four hundred species of moths whose caterpillars enclose themselves in a silk cocoon preparatory to entering upon the chrysalis or quiescent stage of their existence, the silk of commerce has hitherto been almost wholly supplied by one, and that, probably, the most insignificant of them all. The important service rendered to mankind by the mulberry silkworm dates from very early times; for, if Chinese chronology may be trusted, the cocoons of this insect were collected by the inhabitants of the Celestial Empire at least a hundred years before the Noachian flood.

The same people did all they could to prevent the spread of silk culture beyond their own borders. In this, however, they were balked, the seeds of the mulberry tree and the eggs of the silkworm having, it is said, been conveyed across the frontier by a Chinese princess, who concealed them in the lining

of her head-dress while on the way to join her betrothed husband; while two Persian monks are said to have brought the precious eggs to Europe concealed in the hollow of their walking-canes. In Europe the silkworm became readily domesticated wherever the mulberry tree was found to flourish, and for centuries it continued to supply France and Italy with the raw material of a highly prosperous industry.

Twenty-five years ago, however, European silk culture received an almost fatal check in the outbreak among the worms of the disease known as *pebrine*, under which they died in multitudes, while those that succeeded in spinning cocoons furnished only a fraction of the normal quantity of silk. Thus, in France alone, the weight of the cocoons, which in 1853, the year before the outbreak, amounted to twenty-six millions of kilogrammes, had in 1865 fallen to four millions.

The splendid investigations of Pasteur disclosed the true nature of this scourge, without, however, supplying an antidote. Pebrine could be avoided only by rearing such worms as came from the eggs of undoubtedly healthy moths, and Pasteur's investigations enabled him to supply a sure means of discriminating between the moths that were and those that were not diseased. This test consisted in grinding to powder the dead bodies of the parent moths after the eggs had been deposited, mixing

this with water so as to form a paste, then examining a minute drop of it under the microscope, when, if any of the corpuscles characteristic of pebrine were discovered, this was regarded as conclusive of diseased conditions in the eggs, which were accordingly destroyed.

This highly scientific test is now largely applied in France and Italy, and has done much to mitigate the extent of the evil, although adding considerably to sericultural expenses. The deficiency in the quantity of healthy eggs thus produced has given rise during recent years to an important trade in the eggs, or *grain*, as it is termed, of the silkworm. These are chiefly imported from Japan on cards, each containing an ounce weight, or about thirty-eight thousand eggs, the quantity thus annually brought to Europe varying from one million to three millions of ounces and costing on an average two millions sterling.

As those eggs often arrive in Europe at a time when, if hatched, the caterpillars could not obtain the necessary food, a method has recently been devised for retarding their development by keeping them in ice-chests until the arrival of the season most suitable for their growth, and in many places central refrigerating establishments, capable of containing fifty thousand ounces of *grain*, have been erected. In spite of this extensive importation of eggs, the quantity of silk produced in Europe is

decreasing, and silk manufacturers are becoming increasingly dependent on the far East, where labour is enormously cheaper, for their supply of raw silk.

The failure of the mulberry silkworm in Europe has led manufacturers of late to turn their attention to the possible utilization of the cocoons of certain of the other silk-producing moths, and already several Asiatic species have been to some extent naturalized in Europe. The mulberry-feeding silkworms are all small; the other silk-producing moths are among the largest of insects, one of these, the Atlas moth, which has already been bred in England, measuring, in large specimens, ten inches from tip to tip of its wings, and forming a cocoon from two to three inches in length and one inch wide.

A better known species is the ailanthus silkworm, a native of Northern India and China. This moth was introduced into France many years ago by the French Acclimatization Society, and it is now as much at home among the foliage of the ailanto trees, on the leaves of which it feeds, as in its own native haunts. It has already taken its place among the wild insects of France, depositing its eggs and spinning its cocoon without interference from man. Its eggs are hatched in twelve or eighteen days, according to temperature,—the little caterpillars growing so rapidly that in less than four weeks they measure four inches in length and

are ready to begin their cocoon. The latter, it is said, may often be seen hanging in winter on the leafless twigs of the ailanto trees in the vicinity of Paris.

The exceeding fineness of the ailanthus silk filament has hitherto prevented its being reeled, the cocoons on this account being used only as floss silk for spinning. A French manufacturer has, however, recently succeeded in softening the cocoon sufficiently to enable it to be reeled by the ordinary machinery used for mulberry silk. As the tree on which this moth feeds is of rapid growth, and flourishes readily in waste places, while requiring no further attention than is necessary for the ingathering of the cocoons, ailanthiculture, as it is termed, will probably yet become practically important in France.

Another species now acclimatized in Europe is the yama-maï of Japan, which feeds on the leaves of the oak. Its silk is of considerable commercial value, and is now largely produced in Japan. Yama-maï culture has been attempted in England, where the climate is not unlike that of its native country, and where its favourite food is abundant; but, owing partly, it is supposed, to the dampness of our climate, these attempts have not been more successful than have those others made at various times to establish the mulberry silkworm in this country. Experiments by private individuals on a small scale

with both of these species have occasionally succeeded, and good silk has been reeled from English cocoons, but the silk harvest would probably prove too precarious to render British sericulture commercially successful.

India possesses at least thirty-six varieties of silk-producing moths, independently of those which feed on the mulberry, an important contribution to our knowledge of which was recently made by Mr. Wardle in a paper on the "Wild Silks of India." The most important of these Indian forms are the eria silkworm, which feeds chiefly on the castor-oil plant, and from the silk of which a cloth is manufactured so durable "that the life of one person is seldom sufficient to wear out a garment made of it, so that the same piece descends from mother to daughter;" also the tusser silkworm, to which he draws special attention as being, from its abundance and the quality of its silk, the variety most likely to supply an important "silk of commerce."

It is highly esteemed among the natives of India, who reel and weave it into cloth; that it has not hitherto attracted much attention in European markets being probably due to the exceedingly primitive and unsatisfactory methods the natives employ in preparing it. That it can be reeled by ordinary machinery was proved by Mr. Wardle, who had some of the cocoons thus treated in Italy, and who possesses a double unbroken thread reeled from

ERIA SILK MOTH. WITH CATERPILLAR, EGGS, AND COCOON.

one of these which measures fully three-quarters of a mile in length. The introduction of European silk machinery into India would enable the tusser silk to be brought into the market in a more presentable form than at present. The adoption of new methods, however, among a people tyrannized over by caste and other prejudices is always a slow process, and it would probably be more profitable to encourage in India the trade in tusser cocoons, for which there is at present a lively demand among silk manufacturers, leaving to the latter the carrying out of the further stages in the production of silk yarn.

Besides the difficulty in unwinding the cocoons of the large silk-producing moths, a further difficulty lies in the resistance they offer to tinctorial treatment. This difficulty, however, has been to a large extent overcome by the application of various methods in the case of tusser silk. Until recently there was no known method of bleaching it white, so as to enable it to take on light shades of colour. Lately, however, a French chemist succeeded, after bleaching it with binoxide of barium, in removing the natural fawn colour of the silk.

If tusser does not take a dye so readily as mulberry silk, neither can it bear so well the *weighting* process now so prevalent in the manufacture of black silks. In dyeing the yarn for these, it is usual to double or even treble its weight in the

process, and in certain silks shown at a recent exhibition six times the natural weight had been attained. This heaviness is gained by dipping in nitrate of iron, the softness of certain silks being produced by the application of oil and soda, and the rustling of others by acid treatment. If black silks do not last as they used to do, it is simply because in the modern article there is much more dressing than silk. It ought to be considered a good feature in tusser silk that it cannot take on the pile of foreign ingredient now heaped upon the mulberry product.

XXVI.

FLOWERS AND BEES.

As flowers owe their colour, scent, and nectar to the need they have of being fertilized through the visits of insects, they can scarcely be said "to waste their sweetness" so long as this primary object of their attractiveness is attained. They are, however, capable of affording gratification to man in a variety of ways, and it is as instruments of human delectation that they are yet very far from being fully utilized. The fragrance of flowers is enjoyed while they live, but in most cases it is allowed to die with them. In one or two places in the south of England, and still more in the south of France and in Turkey, the flowers of fragrant plants are utilized in the manufacture of perfumery.

The commercial importance of this floral industry is seen in the fact that in Europe and British India alone one hundred and fifty thousand gallons of handkerchief perfume are annually consumed, while the revenue from perfumes imported into Britain is estimated at £40,000. To produce this, an enor-

mous quantity of flowers is required, a large proportion of which are grown on extensive farms at Grasse, Cannes, and Nice, where distilleries exist for the manufacture of the perfume. The largest of these is at Cannes, where, it is said, one hundred thousand pounds of acacia flowers, fourteen thousand pounds of rose petals, thirty-two thousand pounds of jasmine blossoms, and large quantities of other perfume-producing plants, are annually used. The delightful perfume known as "otto of roses" is, however, chiefly produced in Bulgaria, where three thousand pounds of rose petals are usually required for the production of a single pound of otto. The value to Bulgaria of this single flower is seen in the fact that the produce of 1880 was estimated to yield otto worth about £1,000,000.

Dr. Schomburgk, of the Botanic Gardens, Adelaide, strongly advocates the establishment of flower farms in South Australia, where such valuable scent plants as mignonette, sweet verbena, jasmine, rose, lavender, and acacia, "thrive probably in greater perfection than in any other part of the world." To export, however, the flowers to Europe for distillation, as he suggests, would probably prove a mistake, as they would be certain to deteriorate by the way in scent-producing quality, the commercial success of the flower farms of Southern France being due, it is said, in no small measure to the fact that the distilleries are situated in their midst.

A more important product of flowers, and one which is gradually becoming more utilized, is their nectar, which, gathered by bees, is by them transformed into honey and wax. To procure these valuable substances neither flower farms nor distilleries are needed, the bee only requiring a place in which to store the precious load it has gathered from a wide extent of field and garden, and so much of its hoard, or of some cheaper form of "sweet," as is necessary for its sustenance. Nor must it be forgotten that while rifling the flowers of their nectar it recompenses them for it by conveying the fertilizing pollen from flower to flower. The benefit which it thus confers is seen in the case of red clover, which in New Zealand can be raised only from imported seed, owing to the absence of the humble bees, which are its only fertilizers.

The great agricultural and economic importance of the work of bees in this respect was recently pointed out by a Saxon clergyman, who showed that by means of the seventeen thousand hives in Saxony, each containing on an average ten thousand bees, even if only one flower in ten of those visited were fertilized, no fewer than three hundred and forty thousand millions would be thus benefited annually.

Bee-keeping has been known and practised from very ancient times, but it has recently attained its greatest development in the United States, where it

now forms an important branch of industry. In Russia, where honey is used by the peasantry instead of sugar, and mead instead of beer, and where large quantities of wax tapers are employed in the services of the Greek Church, the production of honey is greater than in any other European country, there being in two of its provinces alone nearly one million bee-hives. The Hungarians are famous bee-keepers, there being no fewer than forty hives to every thousand of the population, the total yield of honey in good seasons being about twenty million pounds. In the United States, however, the annual production exceeds thirty-five million pounds.

Bee-keeping in America is carried on by capitalists on a large scale, many bee-keepers having over two thousand hives, while Messrs. Thurber & Co., of New York, have no fewer than twelve thousand. In order to obtain feeding-ground for such enormous numbers, the swarms are farmed out to orchard keepers and farmers all over the country, who, for a fixed rent, allow a certain number of hives to be located on their land. These are visited regularly by experts, who take out the honey, clean the hives, and see to their proper working. An acre of ground will, it is said, support twenty-five swarms of bees, and as each of these should on an average yield fifty pounds of honey in the year, it will thus be seen that the Americans have fallen upon a new

source of wealth in the utilization of the nectar of their flowers.

Mr. Perrine, a Chicago honey-dealer, has recently adopted another method of reaping the honey harvest. He has had a floating bee-house constructed, large enough to accommodate two thousand hives, and this he is now (1879) having towed up the Mississippi from Louisiana to Minnesota, his ship keeping pace as it moves northward with the blossoming of the spring flowers, while on its return journey advantage is taken of a like succession of autumnal flowers. This plan, however, is by no means a Yankee notion, as it was practised in ancient times by the Romans, Greeks, and Egyptians, and is still to some extent applied on the Continent. According to Pliny, when vernal flowers failed in the valley of the Po, it was customary to transfer the bee-hives to boats and to convey them up the stream by night, when the bees in the morning sought honey on fresh pastures, and returned regularly to their floating hives in the evening. This was continued until the sinking of the boats to a certain depth in the water showed that a sufficient store of honey had been obtained. The practice thus described by Pliny is still continued on the banks of the Po. It is also practised in different parts of France, from sixty to one hundred hives being kept on board a single barge.

A similar method was followed in Egypt, where

it was observed that flowers blossomed at least six weeks earlier in Upper than in Lower Egypt, and to take advantage of which boats laden with hives belonging to a great number of different proprietors annually passed up and down the river Nile. It was also customary in Italy and Greece to convey bees by land to districts famous for particular flowers, the Sicilians thus bringing their bees from all parts of the island to Hybla; and in many parts of the Lowlands of Scotland at the present day it is no uncommon thing to see hives conveyed in carts from the outskirts of villages and towns to sojourn for a time among the heather blossoms of the upland districts. This practice of transporting bees by land is also followed in France, where if the weather is warm they are conveyed only by night. During the day the hives are removed from the cart and placed on the ground, when the bees set out in search of honey. As soon as their day's work is over, the hives are again placed on the cart and the journey is continued.

There are few European countries where bee-keeping is in a more backward state than in England and Scotland, although, thanks to the exertions of the Apiarian Societies now flourishing in both countries, a marked improvement is beginning to show itself. The "single straw-hive smotheration m," as the old method has been called, is being ally abandoned, and a more humane as well as

a more profitable system of bee-keeping is being introduced. A great benefit would be conferred on cottagers and rural labourers throughout the United Kingdom were they taught how to manage the small apiary which they might all have in their bit of garden. "Even supposing," says a recent writer on this subject, "the first cost of a swarm to be one guinea, the cottager, with proper care and management, will clear in five years a net profit of nearly £60, and have besides at the end of that period ten good stocks of bees in his garden."

The crop of finely-flavoured honey that is left ungathered on our moors for want of bee-labourers is enormous, but were bee-keeping to become as popular and as well understood among the peasantry of this country as it is among those of Germany, no such waste would be possible. So important is a knowledge of this art considered in Germany, where there are at present over a million and a half of bee-stocks, that the German Government sends paid agents regularly throughout the rural districts to teach cottagers the best methods of bee-keeping, while teachers, before receiving their diplomas, have now to pass an examination in this art. In these days of "extra subjects" in our schools, it might be well to copy the German code in this matter; certain it is that a thorough knowledge of this single art on the part of our rural schoolmasters would be of more service to them and to those

among whom they labour than the smatter of many sciences.

Bee culture has been greatly stimulated by the many ingenious contrivances which have of late years been introduced for increasing the honey-producing capacity of those insects. Chief among these is the "honey extractor," by means of which, through the action of centrifugal force, the full honeycomb can in a few seconds be emptied of its contents without injury to the cells, which are thus again ready for immediate use. As three-fourths of a bee's time is occupied in comb-building under the old plan of removing the comb with the honey, by thus returning the empty honey pots the insect is enabled to devote its whole energies to its mellifluous pursuits. In this way, also, the honey which it requires to eat in order to produce comb material —and for every pound of wax thus formed it is said to consume twenty pounds of honey—is to a large extent saved. The bee-master, of course, obtains less wax, but the loss in this respect is much more than counterbalanced by the great gain of honey which accrues from the use of the extractor.

A machine has also lately been introduced by which tablets of wax are moulded so as to form the foundation of the honey-comb, and in which the side-walls of the cells are started, so that the bee has only to finish them, and thus much time and

wax are saved. Great attention is now being paid to improving the breed of bees by careful selection of queens. These are now reared in special nurseries, and in Italy and Switzerland the raising of Ligurian queen bees for export has grown into a business of considerable importance. With a stock of supernumerary queens always on hand the bee-master can at once supply new swarms, or old ones that may have been accidentally deprived of their sovereign lady, with those absolutely necessary adjuncts to every bee community.

XXVII.

THE UTILIZATION OF CARRIER-PIGEONS.

In this country at the present day pigeons are valued rather for what they are than for any practical service they perform. Pigeon-fanciers rear them for the beauty or singularity of their forms and motions, while naturalists point to them in proof of that plasticity of Nature's species which forms the starting-point of the Darwinian theory. This plasticity, which has enabled man to triple the number of tail-feathers in the fantail, to shorten the beak in the turbit, to swell out the crop in the pouter, and to reverse the neck feathers in the jacobin, has also enabled him to render hereditary in the carrier-pigeon the power of finding its way home from places widely apart. The rock-dove, the original, it is believed, of all our domestic varieties of pigeon, possesses in its strong attachment to the place of its birth, and its consequent desire to return to it, the rudiments of this power; but, as Mr. Tegetmeier lately observed, "one might as reasonably

expect the intelligence and perseverance of a bloodhound from the young of a dingo as the homing faculty of a *voyageur* pigeon from a small-brained, narrow-feathered blue rock." The high state of efficiency to which this power has attained is the result of centuries of domestication and selection; and the attention which is now being given to the breeding of carrier-pigeons by several European governments is certain to bring the homing faculty to still greater perfection.

The pigeon has been employed from very early times as a messenger, figuring, as it does, in this capacity in the Hebrew account of the Deluge. In the East it has from time immemorial been employed for the conveyance of messages between distant points. Thus, winners at the famous Olympic games had news of their victory conveyed with almost telegraphic speed to their distant friends, and Anacreon was following the favourite method when he communicated with his absent mistress by pigeon-post. During the Crusades, also, pigeons were employed, as they have been in later times, for conveying messages between the dwellers in beleaguered cities and the outside world. Before the introduction of the telegraph, pigeons were largely employed in this country for similar purposes. The results of prize-fights and of horse-races were thus quickly made known over the country, while great use was made of this mode of obtaining early information in

the prosecution of stock-jobbing transactions. At an earlier time it was customary, according to Pennant, to let loose those aerial messengers at Tyburn at the moment the fatal cart was drawn away, "to notify to distant friends the departure of the unhappy criminal."

Now-a-days, carrier-pigeons are still used to some extent in the conveyance of private messages, also occasionally by the police in some rural districts of England, and regularly for conveying intelligence from fishing-boats at sea. Early in the present century carrier-pigeons were employed as a means of communication with the Bell Rock Light-house, the birds passing between light-house and shore, a distance of eleven miles, in as many minutes. Their use, however, may be regarded as practically superseded wherever railway or telegraph is available; but in time of war, when these modern methods of intercourse are liable to be cut off, the pigeon-post becomes important as the only available means—excepting balloons—of maintaining communication. The service which it can thus render was strikingly exemplified during the siege of Paris. Throughout the many months when the Germans rendered all ingress and egress by the ordinary channels impossible, carrier-pigeons were passing overhead, conveying messages to and from the besieged Parisians. Fastened to one of their tail feathers was a quill, about the size of a tooth-pick, rolled up in which

there were usually about twenty collodion films. These weighed altogether not more than fifteen grains; yet each bore on its surface printed matter exceeding that of several newspapers. The letters to be sent by pigeon-post were first printed on large sheets, which were afterwards reduced by microscopic photography to one eight hundredth part of their original size; and thirty or forty copies of those reduced photographs on collodion films were usually despatched by as many pigeons, to insure delivery. On arrival at their destination, the birds were relieved of their tiny post-bags, the image on the film was magnified and thrown on a screen, and the letters were then copied and delivered to their owners through the usual channel. More than one hundred thousand of those films were, it is said, sent into Paris during the siege; and, in conjunction with the service of balloons, they mitigated considerably the hardships of the situation. So convinced were both combatants of the value of those birds, that pigeon services on an extensive scale have since been organized in both countries. Every fortress and fortified town in France and Germany is now, it is said, provided with flights of highly-trained pigeons, which, in the event of war, could be sent into those places when invested by a hostile force.

In France the pigeon-service has been placed under the direction of the head of aerial communications; a number of officers and soldiers have been

taught the art of pigeon-rearing, and the birds are being constantly exercised in home-finding. Prizes are also given by Government for pigeon-races. The organization of a similar service in connection with the British army has been advocated, but the necessity for it in a country that has not been invaded for centuries is by no means apparent.

The carrier-pigeon has, however, been recently utilized by the Germans in establishing communication between light-ships and the shore. This was first attempted between the two Eider light-ships and the port of Tonning, in Schleswig, and the success which attended it has led to its organization in other places. The example of Germany in this matter might well be followed by this country with regard to the light-ships around our coasts; for, as was lately pointed out by Mr. Tegetmeier, every soul on board the *Deutschland* might have been saved had the crew of the light-ship only had a carrier-pigeon, under whose wing news of the ship's perilous position might have been sent to Harwich. By the use of the maritime code of signals, as he suggests, two or three letters stamped on the wing would suffice to convey the intelligence that help was wanted.

The best breeds of carrier-pigeons have been known to find their way home from a distance of five hundred miles; and it is not uncommon for press pigeons to bring despatches to London from Brussels, Paris, and even Lisbon. How they find their way home

is still a matter of doubt, but it is probably more by sight than by any other of the senses. On being released they rise to a great height, by a series of circular evolutions, and then dart off in the direction of their homes; but they are brought to a stop, it is said, at night and during mist, when they can no longer observe the usual landmarks. In training them, also, the birds must have comparatively short flights at first, the journeys being extended as the pigeon becomes acquainted with the country over which it travels. That they sometimes make mistakes, and lose themselves, is shown by the considerable number of birds in every pigeon-match that fail to reach home. A certain proportion of those failures, however, is probably due to the pigeons having fallen victims to the attacks of rapacious birds. The Chinese, who from remote antiquity have made use of the pigeon as a carrier, are probably the only people who have adopted means for protecting their aerial messengers from birds of prey. To the root of the pigeon's tail they attach a set of bamboo whistles, somewhat resembling a reed pipe, and these are so placed that as the bird flies through the air they emit a shrill sound, which is said to be effectual in frightening away their winged enemies. When a flock of these pigeons are flying over a town, the sound made by the bamboo pipes is distinctly audible at a very considerable distance.

Experiments have been made with carrier-pigeons

to ascertain if they have the power of flying at great elevations. Tissandier liberated them from a balloon at heights of twenty-two thousand, eighteen thousand, and fifteen thousand feet, and in every case their powers of flight seemed to be paralyzed, the birds falling earthwards like stones. Recently, however, trial was made at the instance of the Swiss Federal Government of their capability of finding their way home from the summit of snow-covered Alps. Two carrier-pigeons—one untrained—were liberated near the top of Jungfrau, at a height of thirteen thousand seven hundred and fifty feet, when it was found that the trained bird reached its cot in the valley eighteen hours after its release.

Considerable differences exist among the various breeds of carriers in the swiftness of their flight. In a recent pigeon-race from the Crystal Palace to Brussels, a telegram was sent to the owner of the birds at Brussels immediately after they had started, but the first of the birds reached home a few minutes before receipt of the telegram, having performed the journey in a little less than five and a half hours. Another pigeon took exactly the same time to reach Penzance from London, a distance of two hundred and seventy miles. Attention was recently drawn to an Icelandic breed of carrier-pigeons of great docility and intelligence, which were said to fly at the almost incredible speed of a hundred and fifty miles an hour—a pair of these, with their

present home in Kent, within ten miles of London, having brought despatches from Paris in an hour and a quarter. The rearing of carrier-pigeons is prosecuted with great success in Belgium, where there are training-schools for the purpose; and it is from the lofts of Antwerp, Brussels, and Liege that the best "homing" pigeons are obtained.

XXVIII.

THE DOMESTICATION OF THE AFRICAN ELEPHANT.

THROUGHOUT the ever-widening area of civilization man's dominion over the beasts of the field is fast assuming one or other of two practical forms—extirpation or domestication. Such "small game" as rats and mice, by reason of their very smallness, will probably escape either fate; and so may such animals as the fox, the hare, and the deer, so long as game-laws exist for their protection, but no longer. If the larger quadrupeds, with the exception of those allowed to remain wild for man's pleasure, are thus destined to death or servitude, it becomes a matter of importance, when it is remembered how much of existing civilization has been rendered possible through the possession of domesticated animals, to see that no creature fit for human service is doomed by man to extinction.

In spite of ample evidence, not only of its natural fitness for domestication, but also of the urgent necessity which exists for its assistance, the African

elephant would seem to be in great danger at the present time of thus dying by mistake. That it is being rapidly exterminated is proved by the increasing difficulty which ivory traders experience with each succeeding year in obtaining the requisite quantity of tusks. Nor can this be wondered at in view of the fact that to supply the one million two hundred thousand pounds of ivory annually imported into Britain, chiefly from Africa, the lives of at least thirty thousand elephants are sacrificed; while a recent writer has calculated that no fewer than one hundred thousand of those animals annually fall victims to the world-wide demand for ivory. There are many animals so prolific that some such weeding of their numbers is absolutely necessary to prevent them becoming a nuisance, but of all creatures the elephant is the one least able to support such a drain on its numbers. It is the slowest of breeders, the female producing only a single young one at a time, and that at intervals of nearly two years.

That it is capable of domestication there can be no reasonable doubt. The ease with which the pair of African elephants lately in the Zoological Gardens of London were tamed, and their evident equality in the matter of docility and intelligence with the better known Indian form, sufficed to dispel the belief in the fierce and untamable character of this species which formerly prevailed. It seems also fairly certain that the African elephant existed

among the ancient Carthaginians in a domesticated state, and that it crossed the Alps with Hannibal in his invasion of Italy; for Roman medals of that period have been found bearing representations of an elephant possessing the enormous ears by which this species is most readily distinguished from that of India.

The Carthaginians, with their civilization, having passed away, the elephant went back to its primitive wildness; and it goes far to prove the alleged inferiority of the negro to the Indo-European races that the former have never yet been able to reclaim it. Their propensity to kill rather than to tame is so strong that, according to Sir Samuel Baker, it is almost impossible to procure live specimens of animals from any of the negro tribes. He could not even bribe them to capture a baby elephant alive for him; and once when he succeeded in doing this for himself, no sooner did he turn his back than they speared it. He never saw, he says, a tamed wild animal or a pet of any description in their villages. That it is the man of those regions and not the elephant that is at fault is rendered probable by the fact that the Indian species, which seems to possess no greater intelligence in the wild state than its African congener, has been from time immemorial under the dominion of man, carrying his loads, fighting his battles, and adding pomp to his pageants.

NEGROES HUNTING THE AFRICAN ELEPHANT.

The extent to which the faculties of the elephant are developed, and his aptness to learn, are all the more remarkable from the fact that almost without exception domesticated elephants have been individually reclaimed from the wild state, some of them when comparatively old; and a recent writer, who had extensive experience in this subject, gives it as his opinion that the old males make the aptest pupils. The dog, it is well known, owes much of its intelligence and other good qualities to the gradual accumulation of good points which it has inherited from a long line of domesticated ancestors, so that the dog of the present is no doubt an immensely superior creature to the first tamed specimen. The elephant, however, has rarely been known to breed in captivity. Its education thus dies with it, and the Hindu, if he wants another, must first catch and then tame it. Its good qualities would thus seem rather to be inherent in the species than acquired through domestication; and for this reason there should be the less difficulty in turning the powerful and sagacious elephant of Africa to more useful purpose than supplying the trader with ivory or the hunter with sport. It is a miserable sight, as Gordon Pasha lately observed, "to see a pile of tusks, and to think that for the sake of a wretched heap of ivory so many noble animals have been killed."

It is as a beast of burden that the elephant is

most urgently required for Africa. The difficulty of obtaining the means of transport for the inevitable baggage of an expedition into the interior has hitherto proved one of the most formidable obstacles to the opening up of Central Africa. Horses, cattle, donkeys, and camels have been tried; but owing to local epidemics, or to the attacks of the murderous tsetse fly, they have proved comparative failures, so that this service is now usually performed by a more or less numerous army of native carriers, each well laden with his own provisions to begin with.

Every reader of works on African travel must be familiar with the unsatisfactory character of this method. The precious time wasted in negotiations with chiefs for a supply of those hitherto necessary evils, their frequent desertions, especially when paid in advance, and their occasional treachery, usually form an immense aggravation of the more legitimate difficulties encountered by the African explorer, and cause him, particularly if he has had experience of the Indian elephant, to long for the subjugation of those still huger animals he sees roaming unutilized around him.

Now that an English settlement has been formed on the shores of Lake Nyassa, which, in order to obtain supplies, must maintain regular communication with the eastern sea-board, the question of providing something more satisfactory than the present system of negro porterage is forcing itself upon the

attention of those interested in the opening up of a commercial route to the populous regions of Central Africa. A railway scheme has already been mooted; but it is not at all probable that the necessary capital could be obtained for what, in the present undeveloped condition of the country, would most certainly prove unremunerative for no one knows how long. The proposed route, however, still abounds in wild elephants, and at a comparatively trifling expenditure the feasibility of employing these animals as beasts of burden might be satisfactorily tested. For this purpose it would only be necessary to import a few tame elephants from India, with a number of attendants trained to the capture and taming of those creatures in one of the Government *keddah* establishments of India. If the African species should prove as amenable as its Indian congener to the domesticating process, as there is little reason to doubt that it would, a sufficient supply of this invaluable means of transport would soon be available. In India, six days after the capture of the wild elephant it has been known to become sufficiently tame to allow a couple of men to mount it without the presence of a domesticated *confrère.*

The advantage of employing those animals in Africa was demonstrated by Lord Napier of Magdala, who was accompanied throughout the Abyssinian expedition by forty Indian elephants, which

were of most essential service in the conveyance of heavy stores over a mountainous country. A similar experiment was made by the late khedive in his equatorial dominions with five Indian elephants, which, on the suggestion of Gordon Pasha, were despatched from Cairo, where they were merely adding to the financial embarrassment of their master by the enormous quantity of food they consumed, to Khartoum. They have since been sent still further into the interior, where they are now employed as carriers of all sorts of heavy goods.

During several weeks' journey through an almost unexplored country they showed their remarkable fitness for such work by thriving, to the astonishment of their keepers, on whatever green food came in their way; also by the ease with which they swam over the broad streams that crossed their path, bearing their attendants on their backs. The elephant, it may here be remarked, is probably superior to all other land animals as a swimmer; in proof of which Mr. Sanderson, in his recently published work on the wild beasts of India, states that a batch of ninety-seven elephants, in crossing the Ganges and several of its large tidal branches, swam for six hours without touching the bottom. The appearance of the khedive's elephants with men mounted on them was sufficient to put to instant flight the natives of the different territories they

passed through—a moral effect that ought not to be lost sight of in estimating the value of the elephant as a factor in future African exploration.

This good work is now being prosecuted by so many nationalities and with such enthusiasm as to render it not impossible that ere long the Lake District of Central Africa will become almost as familiar to the tourist as many lake districts nearer home. The domestication of the African elephant, and its consequent employment as a means of transport, would do much to render such a consummation possible, while it would be the means of rescuing this noble but hitherto abused animal from untimely extirpation.

XXIX.

RECENT ACCLIMATIZATION.

THE distribution of plants and animals has from the dawn of life down to comparatively recent times been left entirely to nature, and hence the value of distributional facts in elucidating the past history of the globe. Thus the presence in bygone periods of huge mammoths and elephants in England has been rightly enough supposed to prove that Britain then formed part of the Continent; for how else could those unwieldy creatures have come hither? And the existence of palm-trees and monkeys in Europe during Miocene times has likewise been held as sufficient evidence that the climate in those days was tropical.

However legitimate such deductions at present are, it is evident that modern civilization with its Acclimatization Societies, Zoological Gardens, and Jamrachs, is doing all it can to render the study of geographical distribution valueless to the geologist of future periods.

No better example of the pickle in preparation for our successors in this field can be found than in Australia. Here, within the memory of people still living, a concourse of plants and animals was to be found altogether unlike anything existing elsewhere, but bearing a striking resemblance to the life that formerly prevailed in Europe during Oolitic times; the deduction from this being that Australia had existed above water since that remote period, and that its insular position had prevented the migration into it of the higher forms of life that were subsequently evolved.

Human progress during the past half century has changed all this: the lowest type of humanity has there given place to the highest; those primitive animals the kangaroo and wombat are being hunted down to make room for the flocks and herds of the settler, who has further surrounded himself with most of the domestic animals of the "old country." The camel is now employed as the "ship" of Australian deserts, the prolific rabbit has become as much a nuisance there as at home, while the house-sparrow hops about familiarly in the streets of Melbourne.

The sparrow seems to have found colonial life exactly to its liking, and so has multiplied exceedingly. The native small birds can no more hold their own against the civilized hosts of sparrowdom than can the naked Australian against the intrusive white population. Even the latter, who hailed the

arrival of the sparrow in Australia with enthusiasm, would now gladly be rid of him. He is accused of robbing the agriculturist of his wheat and fruit crops in wholesale fashion, and the evidence lately taken by a Commission regarding these allegations was so conclusive of passerine guilt that the Government of South Australia now offers a premium of sixpence per dozen on sparrows' heads, while half-a-crown is offered for every hundred eggs.

If Europe has thus wrought utter confusion in the fauna of Australia, the latter has also done something towards producing a similar result in Europe. In England the kangaroo has already been more or less acclimatized, and is, or at least was lately, to be seen in more than one English park consorting with the recently acclimatized eland of South Africa. The future geologist may thus find marsupials, which have been absent from this country since early Tertiary times, reappearing in the latest geological epoch. Australian cockatoos now live and breed in the open air at Northrepps Hall in Norfolk; while the emu, the largest of Australian birds, has been successfully reared both in England and Scotland. The first Scottish brood was raised at Billholm, in Dumfries-shire, in 1877, and the full-grown birds now roam at large to the astonishment of the surrounding rustics; while the second brood was reared successfully during the following season at Restalrig, Leith.

The desire of the Australian colonists to surround themselves with "home" animals, although largely a matter of business, is partly also one of sentiment, and especially is this the case with fishes. These abound in their rivers; but amidst the crowd of strange fish they miss the familiar salmon, sea trout, and river trout, and strenuous efforts have been made from time to time to introduce these from the mother country. It is only in Tasmania, however, that they have as yet completely succeeded. The report of the Salmon Fisheries Commission of Tasmania for 1877–78 announces that the salmon may now be regarded as established in that island, that fish having not only been taken in the form of grilse, but the natural spawning of the adult having also been observed. This occurred in the river Plenty, while in the river Derwent shoals of young and adult salmon were seen, indicating the existence of prolific breeding-grounds. So thoroughly have they now become acclimatized, and withal so abundant, that the colonists are sanguine enough to anticipate that salmon fishing will yet form one of the Tasmanian industries.

Sea and river trout are already abundant in the same waters (the latter also in Australian rivers), and the difficulty, according to the report, now is to prevent over-fishing. In spite apparently of a close time, fishing is believed to be carried on with line, net, and rod all the year round; and the country

is too thinly populated to make the prevention of poaching possible, the temptation to which is correspondingly great owing to the high price which those "home" fish always command. "For a single fish of four or five pounds £1 sterling is frequently paid, and sometimes twice that amount."

With the salmon established in Tasmania, the chances of transferring it to the neighbouring waters of South Australia are greatly improved, and it is not unlikely that this most recent of fishes may yet be found co-existing in Australia with what is probably the most ancient form now living—the ceratodus or mud-fish of the Murray River.

If Victorian waters have hitherto proved too warm for the successful introduction of the British salmon (*Salmo salar*), they have been found better suited for the Californian form (*Salmo quinnat*), which, thanks to the exertions mainly of Sir Samuel Watson, is now found in the waters of Southern Australia. It was lately stated that a fine salmon weighing over seven pounds was caught in a tributary of the Yarra, near Melbourne, and was found to contain a large quantity of well-developed ova.

However valuable these additions to the food fish of Australia and Tasmania may be, they are altogether eclipsed by the advantage accruing to Europe and the world generally from the acclimatization of the Tasmanian and Australian gum-trees. Of these evergreen myrtles there are no fewer than one

hundred and fifty kinds, all confined to that corner of the globe, the most important species being the blue gum (*Eucalyptus globulus*), which has its headquarters in Tasmania. Like so much of the plant and animal life of that oldest portion of the earth's surface, these gum-trees are part of an ancient flora which in Miocene times was common to Europe, where eucalyptus leaves occur in the Miocene beds of Switzerland. A glance at the many valuable qualities possessed by these trees will show how desirable it is that they should flourish once more in their former home. The blue gum is one of the tallest of trees, often attaining a height of three hundred feet, and is altogether unrivalled in the swiftness of its growth, having been known to grow ninety feet in ten years, thus reaching in that period the development of a well-grown oak of a century. It might be thought that such a mushroom-like rate of growth would necessarily produce a soft, porous, and therefore useless timber. On the contrary, however, it is one of the hardest and most durable of woods, rivalling teak in this respect. Unless towards the outskirts of the forest, it seldom bears a branch until the trunk is one hundred feet high, and planks have been cut from it one hundred and sixty feet in length. It is also one of the most difficult woods to burn, and is thus an excellent timber for house-building purposes.

The prejudicial effects of excessive deforesting on

the climate of a country are now generally recognized, and where this has occurred the evil can be most speedily cured by the planting of the swift-growing eucalyptus. The medicinal properties of the gum-tree are now well known. These reside in a volatile oil specially abundant in the leaves, and the presence of which diffuses an aromatic odour through the woods. The Tasmanians found out the antifebrile properties of the leaves long ago, and there is now abundant medical testimony to their value in the cure of intermittent fevers. It is, however, as the destroyer of the fever-producing miasma of marshy regions that it is most widely known, and already over large tracts of malarious country the eucalyptus has proved a veritable tree of life.

Possessing such diverse and important qualities, it is not wonderful that efforts should have been made to naturalize this tree wherever the climate rendered it possible. In this country, owing to the occasional sharp frosts and biting east winds, the attempt has not been attended with much success. The most promising experiment in this direction is probably that being made at present by the Rev. D. Landsborough in the island of Arran. In 1872, three varieties of gum-tree were planted in the open air at Brodick and Corrie, and these have not only lived through the intervening winters, but have grown to a height varying from sixteen to twenty-four feet. This remarkable success so far north is

no doubt largely due to a succession of mild winters, which gave them an excellent start, and thus probably enabled them to survive the rigours of recent winters. About the same time that the gum-trees were planted in Arran a specimen of *Eucalyptus globulus* was planted in a garden at Colintrae in Argyllshire. It was then three feet high and three years old. Little attention seems to have been paid to it, the plant being left through the winter without any protection. So well has it thriven that now (1881) it is forty-five feet high, thirty-three inches in girth six inches from the ground, and twenty-eight and a half inches thick five feet from the ground. It blossomed slightly in 1879, but no flowers appeared in the following summer. As showing the difference of climate on opposite sides of Scotland, it may be stated that on the east coast the eucalyptus has seldom attained to a height of more than ten feet.

The French were the first to recognize the importance of acclimatizing this tree, and now plantations of it are not uncommon in the south of France, which has hitherto suffered much from the absence of forests. Nowhere, however, out of Australia is the eucalyptus found in so great abundance as in Algeria, where the French have already planted no fewer than two million trees. These have proved of the greatest service in increasing the rainfall, but still more in rendering districts, which were formerly

the hot-beds of miasmic fever, wholesome and inhabitable. In his report for 1877, Consul-General Playfair states that at the great ironworks of Mokta-el-Hadiet it was formerly impossible for the workmen to remain over summer and live; they had consequently to be conveyed from a distance daily to and from their work. The Company planted one hundred thousand gum-trees, and now the workmen can with perfect safety remain on the ground all the year round.

In the marshy districts of Southern Spain, in certain parts of the Roman Campagna, and in the swampy jungles of Ceylon, the antifebrile properties of the eucalyptus have been satisfactorily proved; and healthy as Cyprus has been alleged to be, it is proposed to render that "place of arms" still healthier by an importation of those fever-destroying trees. The eucalyptus has spread, wherever climatic conditions have been found suitable, with a rapidity equalled only by the swiftness of its own growth, and a great future may with safety be predicted for it.

XXX.

ANCIENT POLAR VEGETATION.

BESIDES the tale of intolerable cold brought home by Arctic expeditions, which, in the concrete form of thick-ribbed ice and perpetual snow, has hitherto effectually barred their approach to the pole, they seldom fail to secure satisfactory evidence of the former existence of more genial conditions in circumpolar lands. Pine trees have been found prostrate on the site of their growth in greatly higher latitudes than those in which they could now exist, and these, from their still unfossilized condition, give evidence of having lived and died within comparatively recent times. That much warmer conditions prevailed at a still earlier time is evidenced by the fossil plants found in some of the most northern lands yet reached. These include many evergreen shrubs, oaks, maples, beeches, poplars, and walnuts, while two species of vines have been found fossil in Greenland. *Sequoias* also, allied to the mammoth trees of the Yosemite region of California,

have been found in Spitzbergen, with water-lilies and the swamp-cypress of the Southern United States in Grinnell Land, within eight degrees of the pole.

Judged by its plant remains, Greenland would appear to have possessed in Miocene, or, as many geologists are now inclined to believe, in Eocene times, a climate as warm as that of New York or St. Louis, and a vegetation richer than that of Southern Europe at the present time. And the pole itself, or at least its near neighbourhood, would probably have compared favourably in climate and vegetation with Scotland of to-day.

Geologists are agreed in regarding the presence of such a flora as conclusive evidence of the former existence of a warm polar climate; hitherto, however, they have been, and to some extent still are, divided on the question of accounting for it. Some have attributed it to the passage of the solar system through a warmer region of stellar space, others to alteration in the position of the poles. Buffon held that as the globe once existed in a state of incandescence, from which it has been gradually cooling ever since, life first became possible at the poles, where for long ages a tropical climate must have been enjoyed. This theory, however adequate in Buffon's time, before the existence of a glacial epoch had been dreamt of, is now generally abandoned as no longer in accordance with known facts. It is somewhat surprising, therefore, to find a geologist of

Count Saporta's reputation adopting this discarded hypothesis as the basis for his recent theory of the northern origin of plant species. Any theory to be satisfactory now must explain, not the occurrence of a warm polar climate merely, but of what Dr. J. Geikie has termed the "rotation of climates"—the alternating hot and cold periods which geologists have now succeeded in establishing.

Sir Charles Lyell sought to account for both on the ground of altered distribution of land and water—a period of wide-spread warmth inevitably following, as he supposed, from the aggregation of the chief land surfaces around the equator, with the polar ocean open to the ingress of warm currents generated in equatorial lands; while a glacial period would necessarily result from a similar aggregation of land around the poles. It is generally admitted that climate is affected in no small degree by the mode of land and water distribution; the climate of Britain would thus be considerably altered by any upheaval of the sea-bottom which would divert the Gulf Stream from its shores. By the majority of geologists, however, this theory is regarded as inadequate to account for changes so decided as those which marked the glacial epoch. The theory which now meets with most acceptance is that which attributes climatic changes to astronomical causes, and especially to the eccentricity of the Earth's orbit—a theory associated with the

name of Dr. Croll, lately of the Geological Survey of Scotland.

The Earth's path round the Sun is elliptical in form, with the Sun not in the centre but to one end of it, so that the Earth in its yearly revolution has a point of nearest approach to, and one of farthest distance from, the Sun, the Earth being in *perihelion*, as it is called, when nearest, and in *aphelion* when farthest from, the Sun. Its orbit, however, is constantly varying in form within certain limits, from being almost circular to having an eccentricity which, at its maximum, brings the Earth when in perihelion thirteen million miles nearer the Sun than when it is in aphelion. As the Earth quickens its speed the nearer it is to the Sun, and as the perihelion part of its journey is actually shorter than the other, it accomplishes the former in less time than it does the latter, and this is a point of great importance in the astronomical theory of climatic change.

At the present time mid-winter in the northern hemisphere happens when the Earth is nearest the Sun. It is consequently shorter and warmer than the same season in the southern hemisphere, which occurs when the Earth is farthest removed from the centre of light; and although the eccentricity of the Earth's orbit at present is only such as to put the inhabitants of the southern half of the world three million miles farther from the Sun in mid-

winter than we are, yet this is probably the chief cause of the much severer cold which now prevails in Antarctic regions. The winter of the northern hemisphere, however, has not always happened when the Earth was in perihelion, nor will it always continue so to happen. Owing to astronomical causes, which cannot here be detailed, a complete revolution in this respect takes place every ten thousand five hundred years, on the expiry of which the southern hemisphere will have its turn of winter in perihelion. In order to produce another glacial epoch over the northern half of the globe, it is mainly necessary, according to Dr. Croll's theory, that winter should there occur in aphelion during a period of maximum or at least very great eccentricity of the Earth's orbit. Winter with us would then last about thirty-six days longer than summer, while it would receive one-fifth less heat than it now does during the same season. It would, however, get one-fifth more heat in the short hot summer, and this, it might be supposed, would be sufficient to counterbalance the excess of winter cold. Such, however, Dr. Croll has conclusively shown would not be the case. Looking to the trifling effect produced on the Greenland ice-cap at the present day by the hot summer of that region, there can be little doubt that during a period of maximum eccentricity the intense heat of the short summer would not suffice to melt the mass of snow

and ice that would collect during the long cold winter. The ice and snow would thus go on accumulating, its presence all the year round helping to intensify the cold, and thus to increase its own bulk, until a great part of the northern hemisphere would again become swathed in glacial robes. A very different result, however, would ensue in the southern portion of the globe. There, summer, happening while the Earth was farthest removed from the Sun, would be long and cool; while the winter succeeding it, owing to the Earth's proximity at that season to the Sun, would be short and warm, and thus there would be brought about a condition of perpetual spring.

Dr. Croll has further shown how, as the cold in the northern hemisphere became more intense, such warming agencies as the Gulf Stream might, under favourable conditions of land distribution, be turned southward, and thus still further warm that region, which then would not be far removed from a state of constant summer. In the same way, at a time of maximum eccentricity, with the summer of the northern hemisphere in aphelion, a climate sufficiently mild for the growth of the Tertiary polar plants would be produced.

This astronomical solution of the problem of climatic change likewise supplies the geologist with what his science is, and probably always will be, greatly deficient in—namely, chronological data.

Thus the last period of high eccentricity can be demonstrated to have occurred two hundred and ten thousand years ago, and those who adopt the theory regard this as probably marking the time of the last glacial epoch; while a still more eccentric period occurred eight hundred and fifty thousand years ago, when there must have been in the northern hemisphere severe glacial conditions alternating with others of a more genial kind, according as the Earth in summer was near or distant from the Sun, and to one of these warm periods the polar Miocene flora is probably to be attributed.

However mild the climate of circumpolar lands may then have been, it seems difficult to understand how plant life could thus have flourished where darkness prevailed for nearly four months of the year, and many theories have been started, such as the greater diffusiveness of sunlight in early times, in explanation of it. Most botanists, however, have come to regard all such theories as unnecessary, for, granted a sufficiently high temperature, with low winds, the long polar night would not, in their opinion, prevent the survival of a warm temperate flora; in proof of which it has been stated that although the hot-houses in the St. Petersburg Botanic Gardens are matted up for six months in the year, the prolonged darkness thus produced does not prevent the cultivation of tropical palms.

Abundant evidence of the occurrence in Arctic

and sub-Arctic regions of a series of warm periods extending as far back as Silurian times, is found in the fossils of the various formations represented in their strata. The remarkably complete succession of fossil floras there met with, and their marked resemblance to those of lower latitudes, form one of Saporta's arguments in favour of his view that the circumpolar area has been the birthplace of plants and the centre of their dispersal or migration—a theory which, in its main features, has received remarkable corroboration from the recent investigations of Dawson, Dyer, and Gardner. The rich vegetation of circumpolar lands in Eocene times migrated southward as the climate gradually grew colder, giving place to the modern Arctic flora, which in turn crept slowly southward as the cold of the glacial epoch gradually became more intense, until at length a truly Arctic flora abounded in Central Europe. As the climate slowly ameliorated, the Arctic plants, in order to find suitable conditions, migrated northwards, unless where the presence of mountains enabled them to obtain the necessary cold by climbing upwards instead of polewards. The present alpine flora of the Pyrenees, the Alps, Britain, and Scandinavia, chiefly resembling as it does the vegetation of the Arctic regions, is thus, as Dr. A. Geikie recently expressed it, "a living record of the Ice Age."

XXXI.

THE MAMMOTH.

In coming upon the elephant after having gone the round of that epitome of the animal world, the Zoological Gardens of London, one feels at last in the presence of a living relic of a past order of animated things—a fit congener of those antediluvian monsters whose restored forms give picturesqueness to the architecture of the new Natural History Museum at South Kensington. The elephant is like nothing else in the Gardens, or, for that part of it, in the whole domain of living things. Unlike man, it has no relations, poor or otherwise. Naturalists now-a-days regard mankind as but one of four families forming the order *Primates;* and it is a pleasing sight, as one passes through the monkey-house in Regent Park, to see how cordial are the relations subsisting between the juveniles of the superior family and the members of the other three. The elephant, however, is spared the necessity of wishing to be saved from his friends, by not having

any. They have all joined the majority long ago; and now the Indian and African elephants stand alone—the sole living representatives of an entire order of mammals.

That they themselves are fast hastening to the extinction which has overtaken the others seems certain. The demand for ivory is so great, and the reproductive powers of the elephant so small, that the African species is becoming rapidly scarcer; nor is this to be wondered at, seeing England alone requires the annual slaughter of thirty thousand of these animals to supply her demand of one million two hundred thousand pounds of ivory. Even the domestication of the Indian species will not, it is to be feared, long retard its apparently inevitable extinction; for, unlike all other domesticated animals, the elephant does not breed—at least there are only a very few instances on record of its having bred—in captivity. Elephants have all to be reclaimed from the wild state, and the death-rate among those reclaimed is very high. It is not probable that in a country with a rapidly increasing population like that of India the stock of wild elephants will be other than a gradually diminishing quantity.

One does not need to go far back in geological time to find the elephants a much more dominant and flourishing group. In the comparatively recent Miocene period India is known to have had no fewer than six kinds of elephants, and these, at the

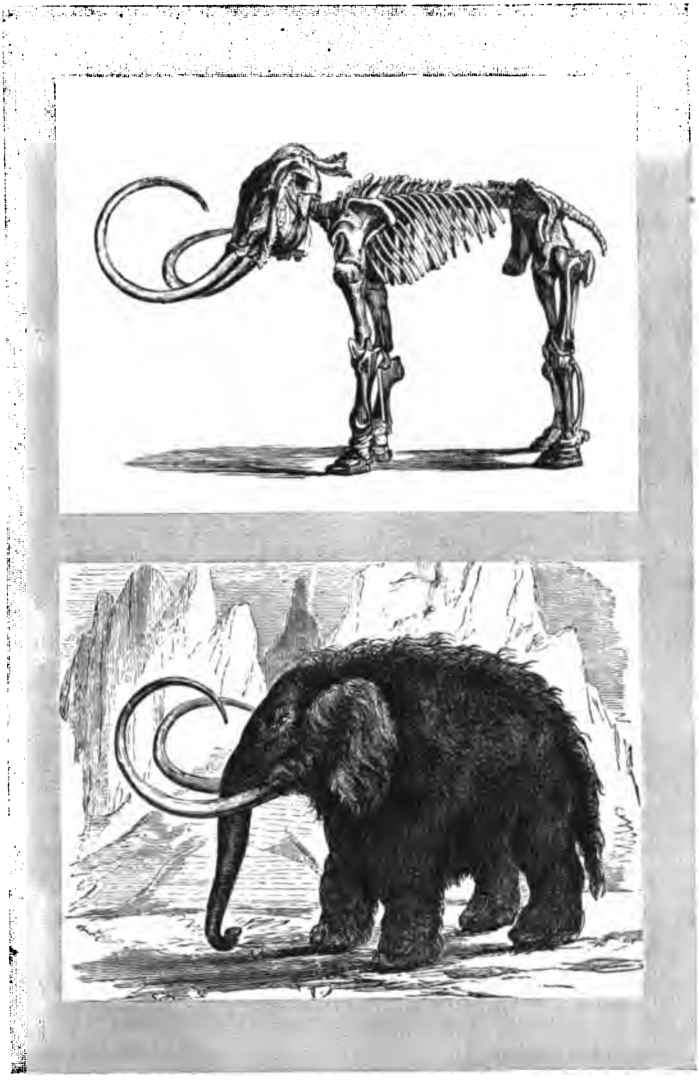
same time, had near relations in the several species of mastodons, and more distant ones in the huge *Dinotherium*. At a much later period Britain alone had its three species of elephants, the bones of which have been found in great abundance, especially off the coast of Norfolk, where in thirteen years the fishermen dredged up from an oyster-bed no fewer than two thousand elephants' molars. These belonged to the extinct elephant known as the mammoth—a name which many believe is merely a Russian corruption of the Arabic behemoth.

That the mammoth co-existed with the human race there cannot be a doubt, as a drawing of it has been found on bone, etched by pre-historic man; and Sir J. Lubbock believes that our predecessors in Britain hunted it, just as the wild tribes of Africa and India now hunt the elephant. The belief, indeed, at the present day is gaining ground that the mammoth may be said still to exist, in the same sense in which many naturalists believe that the *Urus* of Cæsar survives, although degenerate, in the wild cattle of Cadzow and Chillingham—namely, in its descendant the elephant of India. The differences in teeth and bones are more matters of dimension than of form; externally, however, the differences are more marked, the mammoth having been clothed with thick wool and hair, while the elephant, if a few hairs scattered here and there on

its body be excepted, is naked. There are certain facts, however, which tend to reduce this difference to a matter of literal hair-splitting: for example, the elephants found in the cold Himalayan region are much better endowed with hair than their brethren of the hot plains; while baby elephants, according to Darwin, are at their birth hair-covered. Now, it is generally recognized that there is no surer way of ascertaining the ancestry of an animal than by a study of the characters of its young—the younger the better—and the fact that the baby elephant is thus clothed affords strong presumptive evidence that it is the descendant of a hairy ancestor.

There is a marked tendency in animals which in cold climates have a thick coat of hair to lose it in tropical countries: thus there are the hairless dog of Egypt and the nearly hairless buffalo of India, and there are many animals whose fur grows thick in winter and thins again in summer. The nature of the coat is thus seen to be largely dependent on climate. According to the Darwinian theory, new species are simply old ones altered to suit changed conditions; and in this view the Indian elephant may be merely the mammoth altered by heat and other tropical conditions.

Few animals, living or extinct, have enjoyed so wide a geographical range as the mammoth, its remains testifying to its presence throughout North



THE MAMMOTH.
(1. Skeleton. 2. Restored.)

America, while, with the exception of Scandinavia, it has been found everywhere in Europe. Siberia, however, appears to have been the special home of the mammoth, where its remains occur in increasing abundance the farther north we go. So abundant, indeed, do they become on the river-banks and tundras bordering on the Arctic Ocean, that in such localities as the Bear Islands and New Siberia the ground is said to be largely composed of its bones and those of its contemporaries.

These are the localities which form the great storehouses of the fossil ivory—the tusks of the mammoth—which have been the main source of the supply of that material to the Russian Empire for centuries. The Arabs are believed to have been the earliest traders in fossil ivory, which they are said to have obtained from the merchants of Khiva; and thus it may have happened that the unknown creature whose tusks they trafficked in became known under an Arabic name. This ivory is often obtained as fresh and white as the best African, and enormous quantities of it have been collected during the past two centuries,—the supply from Northern Siberia having been known to reach in a single year two thousand poods, or eighty thousand pounds. Some of the fossil ivory is imported into Liverpool, where it finds a ready sale among comb-makers and other workers in ivory.

What length of time may have elapsed since the

final disappearance of the mammoth no one knows. The Samoyedes still, it is said, preserve traditions of its existence; while many of the northern tribes of Siberia are in the belief that it lives, but that it leads a subterranean life, death being the immediate result of its appearance on the surface. The origin of this curious belief is readily found in the fact that occasionally, after landslips on the banks of the Lena and other Siberian rivers, entire carcasses of the mammoth have been disclosed as fresh as if they had been sides of beef brought from America in the refrigerating chamber of a steamship. How they got entombed in such numbers is matter for controversy; one thing, however, is certain, that having been entombed the freezing process must have been immediate, and there can have been no thawing of the ground since, as otherwise putrefaction would have at once set in.

Mr. Howorth has given most of the known instances in which the soft parts of the mammoth have been thus found preserved, the most remarkable of these being probably that of the specimen visited by Mr. Adams early in the present century. It was first noticed by a native hunter projecting from a cliff of frozen soil on the banks of the Lena. It gradually became more conspicuous as summer after summer the ice about it continued to melt away, until at last it rolled out of its icy shroud and fell on a bank of sand, where the hunter get-

ting at it removed its valuable tusks. Afterwards the natives in the neighbourhood fed their dogs with its flesh, while it was visited for a like purpose by white bears and wolves.

When Mr. Adams saw the creature two years afterwards, little remained of it but the skeleton and about three-fourths of the skin—the latter being covered with reddish wool and long coarse hair, while its weight when detached from the bones was such that ten persons had great difficulty in transporting it to the shore. The tusks, which had been sold as fossil ivory, were recovered, and measured nine and a half feet in length, and the whole specimen was conveyed to St. Petersburg, where it is now preserved in the Zoological Museum. Similar remains have frequently been found in strata of clear ice, and so well have the soft parts in many of these been preserved, that it has been found possible to prepare microscopic sections of many of the more delicate tissues. It need hardly be said, however, that this perfect preservation of the flesh is no proof whatever of the recentness of the mammoth, as, granting the persistency of similar glacial conditions, putrefaction would be arrested for an indefinite length of time.

The mammoth, it is certain, could not exist under the climatic conditions which now prevail in Northern Siberia, the ground for three-fourths of the year being covered with snow, and during the

brief summer with the scantiest vegetation. Even could the mammoth, with its shaggy covering, have endured the cold, it could not possibly have found sufficient food. The nature of the plant and shell remains found associated with it seems, however, to indicate that during the epoch when this mighty pachyderm and its contemporary, the woolly rhinoceros, flourished, the climate of Northern Siberia must have been somewhat milder and more equable than it is now—a change which Sir Charles Lyell has shown may have been due to the gradual extension of the land along the Arctic shore. The increasing severity of the winters, and the consequent decreasing supply of food, would no doubt contribute to the final extermination of the mammoth and its associates.

Could it be supposed that this change of climate came over Siberia with a suddenness like that of an earthquake, a ready method would be afforded of explaining the existence of fresh carcasses of the mammoth at the present day. We have no experience, however, of such sudden changes of climate, and to believe in their former occurrence is altogether contrary to that doctrine of uniformity which increasing knowledge only tends to confirm. So convinced, however, are many naturalists of the inadequacy of every other theory to explain the preservation of the soft parts, that they adopt the view that in this case nature acted suddenly and

per saltum—that the frost came down as suddenly and as fatally upon the mammoth herds as did the destroying angel upon the hosts of Sennacherib, and that it has ever since kept them and their country in bands of ice. It may be safely presumed that geologists generally will prefer to continue speculating on the possibility of these frozen mammoths having got thus entombed during some migration northwards, or through being swept into icy regions by the floods which annually pour down the Siberian river-courses, rather than have recourse to the once favourite but now justly discredited cataclysmic theories.

XXXII.

MAN'S AGE IN BRITAIN.

THE date of the first appearance of man in Britain, or indeed anywhere, could only be a matter of secondary importance to those who believed that some sixty centuries ago he was nowhere. When ethnologists, however, discovered that four or five thousand years ago such well-marked races of men as the Syrian and the negro—the descendants of a common stock—already existed, it began to be felt that in the short preceding period the Ethiopian could not possibly have had time to change his skin by any natural process. The philologist had also a similar difficulty in accounting for the growth of so many languages out of one common tongue in so limited a period, while the more the geologist learned of his science the less adequate for his purpose did the old chronology appear. The much greater antiquity of the human race is now generally recognized, and anthropologists, no longer "shackled by the bonds of a short chronology," are now free

to fix man's age according to ascertained geological evidence.

The Anthropological Exhibition at Paris in 1878 proved the rapid progress which is being made in this direction. Flint implements and other undoubted specimens of human workmanship were exhibited from almost every country of Europe, where they had been found in conjunction with the remains of the mammoth and other extinct mammals, thus proving the existence throughout that continent of what is known as "Quaternary man." Still more interesting, however, were those remains which, if finally accepted as of human workmanship, would carry man's first appearance on the earth back to an immensely remoter period—namely, to Middle Tertiary times.

These consisted chiefly of the late Abbé Bourgeois' collection of flint implements from the Miocene strata of Thenay. Those flints had evidently been subjected to the action of fire, many of them being simply fire-split; others again—and on these the abbé chiefly relied in proof of their having been intentionally fashioned—show signs of being afterwards chipped on one or both of their margins. This discovery has now been twelve years before Continental geologists, and much of the scepticism with which its first announcement was received has disappeared on further investigation of the strata at Thenay, and in view of the confirmatory evidence

which has been obtained from other sources. Thus, at the same exhibition, another French observer showed flint implements which he had recently discovered in the Upper Miocene strata of Aurillac, in company with remains of the extinct mastodon and dinotherium. These tools exhibited a slight advance upon those of Thenay, most of them having been split by tapping and afterwards dressed on their margin. The director of the Portuguese Geological Bureau also exhibited a somewhat similar collection of flints and quartzites from the Miocene of the Tagus. The result of these discoveries has been, as Professor Dawkins stated at a recent meeting of the British Association, that in France it is accepted that man was living in the Miocene age.

No other species of mammal then living has survived to the present day, and for this reason Professor Dawkins declared that he would have less difficulty in believing that those Miocene flints were the work of some of the higher and extinct forms of monkeys than that man had thus been an exception to the general rule of extinction. This, however, is practically the view held by French *savants*, or at least by those of them who accept the doctrine of evolution. They regard the flint implement makers of the Quaternary period as constituting probably a distinct human species, while Tertiary man is considered as even more than specifically distinct. In a recent article in the *Revue d'Anthro-*

pologie, De Mortillet says—"Tertiary man must have been of a species still less like the present human species than early Quaternary man—indeed, so different as to entitle him to be regarded as of distinct genus. For this reason I have given to this being the name of man's precursor; or he might be called Anthropopithecus, the man-monkey." According to this French anthropologist, therefore, those flint implements are in reality the handiwork of one of those much-desiderated missing links between man and ape.

By the majority of English geologists the evidence that man existed anywhere in Tertiary times is not regarded as satisfactory. No trace of him or of his works is to be found in British Tertiary strata, although it ought to be stated that the Miocene rocks of that period which have yielded the French remains occur only in a few small patches in this country. Man's first appearance in Britain is unanimously relegated to Quaternary times. Those times, however, were immensely protracted, including as they did what is now known as the great Ice Age, and it has long been a vexed question among English geologists whether man inhabited Britain before the advent of the Glacial epoch or only after its close—whether, in fact, he is to be regarded as pre-glacial or post-glacial.

The sole evidence of the presence in this country of palæolithic man—the unpolished Stone folk—lies

in the remains of himself and of his works found buried in cave-deposits and river-gravels. Many of the limestone caves of England are believed to have existed as such since Tertiary times, and to have formed the dens of the wild animals which have in succession occupied this country, and whose bones as well as those of the animals they preyed upon have been left to mark their former presence. They also formed at times the homes of palæolithic man, who has left abundant traces of himself in the rude stone implements which are found intermingled with the other mammalian remains. Those caves have for many years past been in course of systematic exploration under the auspices of the British Association and other societies, and have already thrown much light on the early history of man in Britain.

In Victoria Cave, near Settle in Yorkshire, flint implements have been found commingled with the bones of the hyena, fox, cave-bear, badger, elephant, rhinoceros, hippopotamus, reindeer, and horse; while the other caves explored, as well as the ancient river-gravels, have yielded a somewhat similar assortment of animals. The presence in those caves, in what appeared to be contemporaneous strata, of animals now belonging to such widely separate regions of the world, led geologists to inquire what the climatal conditions could be which permitted the co-existence in England of the hippo-

potamus of the torrid, the reindeer of the arctic, and the horse of the temperate zones. Some have sought to explain it by supposing the existence of strongly contrasted summer and winter temperatures, when the intense heat of summer attracted the hippopotamus, the hyena, and the lion northward; while the equally severe cold of winter again drove them south, and filled their deserted cave-dens with an invasion from the north of white bears, reindeers, and musk-oxen. This theory has, however, been pretty generally abandoned in favour of that which attributes the apparent commingling of such diverse animals to the occurrence of occasional mild periods during the course of the great Ice Age, when the fauna of the warmer regions spread northward, until again driven back by a new accession of cold.

If this theory be correct, the occurrence of flint implements commingled with these heterogeneous mammalian remains would prove that palæolithic man existed in Britain at least during inter-glacial times; and since this view was first advocated by Professor Geikie in his "Great Ice Age," certain facts have been discovered which seem to put it beyond all doubt. In excavating the floor of the Victoria Cave in Yorkshire, Mr. Tiddeman found a bone, which several anatomists recognized as a human fibula, lying beneath a bed of stiff glacial clay,—proving that man had been there at least before the

advent of the latest cold period; but some doubt, it would seem, now exists as to the human character of the bone, so that the question cannot be regarded as decided by this specimen.

Lately, however, Mr. Skertchly has obtained evidence of man's presence in Britain before the close of the Glacial epoch. At Brandon, in Suffolk, he has discovered flint implements of palæolithic type embedded in brick earths, which, when well exposed, are seen to underlie, and are therefore older than, what is known as the "chalky boulder-clay," which is undoubtedly of glacial origin. Many of the stone implements which abound in the cave-deposits of England may be as old or even older than those of Brandon, but owing to the absence of glacial cave-deposits this point cannot be satisfactorily settled; so that, as far as our knowledge goes, the implements of the old Stone folk of Suffolk offer the earliest evidence of man in Britain. The last Glacial epoch is believed to have occurred about two hundred and ten thousand years ago, and there is a strong probability that man was an inhabitant of some of the English caves before the commencement of that epoch. Certain it is, at all events, that he was here before it passed away, and was therefore witness of the many remarkable changes which geologists tell us have taken place since that period in the climate and geography of those islands.

XXXIII.

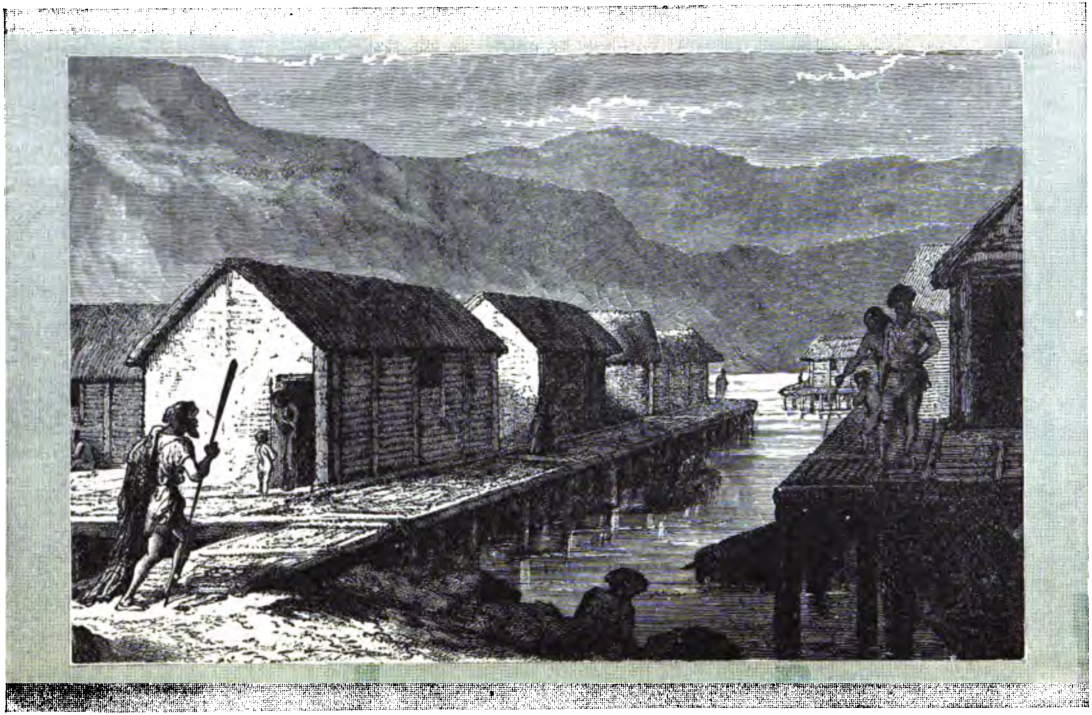
LAKE-DWELLINGS.

OF all the sites on which man has chosen to fix his "local habitation," few commend themselves less to modern ideas of comfort and convenience than that of the lake-dwelling. It is no less certain, however, from the extraordinary persistence and wide distribution of lacustrine abodes, that such a position must have been well adapted to the circumstances of very many savage and semi-savage communities. Twenty-two centuries ago Herodotus, in describing how Megabazus failed to conquer those Pæonians who dwelt on the Thracian lake Prasias, states that their houses were built on platforms supported by wooden piles placed upright in the middle of the lake, and only accessible from the shore by means of a long narrow bridge. The piles of the platform had been originally fixed in their places by the whole body of citizens, but afterwards they were maintained and extended through the action of a law by which a man had to set up three piles for every wife he

married. Each family had its own hut, which communicated with the water beneath by a trap-door, and the historian adds that it was customary to tie the baby children by the foot with a string to prevent them rolling into the water.

Three centuries ago the Spanish conquerors of South America found similar dwellings on Lake Maracaybo, and for this reason they called the surrounding province Venezuela, or little Venice; while so recently as 1874 Commander Cameron, in his walk across Africa, came upon similar communities on Lake Mohyra. This lake was only two miles long by one broad, yet it contained three villages built on piles and several detached huts. The only means of communicating with the shore was by canoes, which were simply "dug-outs," or by swimming, which seemed to be the favourite mode of passing from house to house. The inhabitants, as might be expected, were extremely suspicious of strangers, and Cameron entirely failed in his endeavour to obtain canoes with the view of opening up intercourse with them; not even the flaunting of the most seductive bits of cloth and beads before the eyes of some who had landed on shore was sufficient to prevent them "taking the water" on the first sign of his intention to approach.

There is thus abundant evidence of lake-dwelling during the historic period. It was, however, but recently discovered how important a part it played



A SWISS LAKE VILLAGE.

in pre-historic times. The fishermen on the lakes of Switzerland had often observed, as they rowed in calm weather over the smooth surface of the water, wooden piles projecting from the muddy bottom, with the antlers of deer and other remains; but these did not attract the attention of Swiss antiquaries until the dry season of 1854 had lowered the height of the waters to an unprecedented extent, turning the shallow margins of the lakes into dry land. To keep hold of the ground thus abandoned by the waters, the inhabitants in many parts raised its height with mud taken from the water's edge. In doing so the long-forgotten lake-villages were brought to light, with abundance of such records of the ancient inhabitants as their canoes, their weapons and implements of stone, bronze, and iron, their household utensils of wood and horn, the remains of the animals they hunted and of such as they had thus early domesticated, of the crops they grew on the neighbouring shores, of the bread they baked, the flax they spun, and the cloth they wove.

Some of the villages seem to have belonged exclusively to the Stone age, others to that of the Bronze, while in many there was a mingling of the implements of both. Most of the Swiss lake-villages bear marks of having been destroyed by fire—the work, possibly, of the iron race, which, though it conquered, does not seem to have occupied the dwellings of the bronze communities. Strong in the possession of

iron weapons, the new race prepared to defend itself against all comers on shore.

The majority of the Swiss lake-dwellings resembled those described by Herodotus in being built on platforms supported on a series of piles. A few, however, and those chiefly in the shallow waters of the smaller lakes, had their platforms supported on horizontal layers of wood built up from the bottom, these being kept in position by upright piles. They were, in fact, artificial islands, and bore considerable resemblance to the peculiarly British form of lake-dwelling known as the *crannog*, or wooden island. Crannogs are very numerous in the lakes of Ireland, and about fifty of them had been described before the Swiss lake-dwellings were discovered. In some cases they are wholly artificial, being formed of wood, stone, and clay, raised above water-mark, and the whole surrounded with a stockade of piles; in others a low-lying islet has been utilized as a base for further operations. It is probable, however, that while the Swiss dwellings formed the permanent homes of whole tribes—for it has been calculated that some of the platforms were large enough to accommodate three hundred and eleven huts—the Irish crannogs served rather as places of refuge or of defence, to which the shore-dwellers had recourse in troublous times. A few of the latter, however, are large enough to have each formed the site of a village. Ancient as the foundation of these "wooden islands"

must have been, they continued in use long after the Swiss lake-dwellings had disappeared beneath the water—allusions to them as places of strength being numerous in ancient Irish records; nor do they entirely drop out of history until the middle of the seventeenth century.

The discovery of those Irish antiquities drew attention to the subject of lacustrine abodes in Scotland, with the result that examples of Scotch crannogs, similar in almost every respect to those of Ireland, have now been found in different parts of the country. The most remarkable of these discoveries was probably that of a group of crannogs in Dowalton Loch, Wigtownshire, described by Earl Percy at the meeting of the British Association in 1863. Interest in this ancient form of dwelling has been reawakened by the discovery of a crannog on the farm of Lochlee, near Tarbolton in Ayrshire, and thanks to the care which has been taken by the Archæological Society for the counties of Ayr and Wigtown to have it thoroughly investigated, it has supplied much valuable material to Scottish antiquaries.

Forty years ago this crannog was covered by the waters of a loch which extended over a considerable portion of the present farm. It was exposed, however, shortly after by the complete draining of the loch, when it attracted the attention of the curious in the neighbourhood from its artificial appearance,

and still more by the discovery of two canoes in the bed of the lake. Its real nature, however, does not seem to have been suspected—a thing not to be wondered at, seeing that neither Swiss "Pfahlbauten" nor Irish crannogs had as yet been described, although it is a somewhat remarkable coincidence that the first of the latter was discovered and examined during the year in which Lochlee was drained. Having thus narrowly escaped fame forty years ago, the ancient bed of Lochlee has since known no further change save that produced by the inevitable rotation of crops.

Re-draining operations, however, were lately commenced, and these have led to the opening up of the mound, and the discovery of the characteristic features of the crannog. From the excavations which have been carried out, the structure would appear to be circular in form, and about forty yards in diameter. It is surrounded by a stockade of young oak trees, which in some instances are fixed directly into the mud of the lake-bottom, and in others fit into holes in horizontal beams. The interior of this artificial island appears to be formed of woodwork, interspersed with large stones and masses of clay. Near its surface there are the decayed remains of a rude platform formed "of rough planks and saplings lying on beams of split oak trees." In cutting a trench through the mound two stony pavements were come upon near the centre,

each resting on a bed of clay, which from the surrounding remains of ashes, charcoal, and burnt bones, had evidently been fire-places, and still lower the clay of a third hearth was discovered. The existence of these fire-places, one above the other, would seem to indicate that during its occupation the water had been gradually gaining upon the crannog, and so necessitated the raising from time to time of its surface. Similar indications have been met with in several of the Irish crannogs. Unlike most of these, however, it seems to have been connected with the shore by a gangway, three rows of closely-set piles having been found to extend from the mound to the mainland.

Among the remains which have been dug up are a canoe, hollowed out of a single tree, querns, bone chisels, hammer stones, a spindle-wheel, deer-horns with marks of cutting upon them, boars' tusks, and a great variety of the bones and teeth of animals—the latter including fragmentary remains of the reindeer. A considerable variety of metal objects were likewise found, including spear-heads, daggers, chisels, a three-pronged instrument, and a saw thirty-eight inches in length, all made of iron; also three fibulæ, one of them elaborately ornamented, a finger-ring, a bridle-bit, and several other objects of bronze or brass. Among other evidence of progress in the arts there was a piece of curiously carved wood, a fragment of red pottery, and one or two other speci-

mens of the ceramic art. Many of the bones were found when broken to contain beautiful green crystals of the mineral known as *vivianite.*

The objects thus found, representing as they do the weapons, the implements, the ornaments, and the domesticated animals belonging to those ancient lake-dwellers, throw considerable light on the extent of their civilization, and have enabled archæologists to assign the Lochlee crannog with tolerable certainty to what is known as the Late Celtic Period.

XXXIV.

SOME AMERICAN FOSSILS.

THE British agriculturist is not the only one to whom the States of the "Far West" offer a tempting field of operations. To the man of science, and especially to the palæontologist, they are equally alluring. The fossiliferous strata of the mother country have been so thoroughly ransacked of their ancient life-treasures, that the discovery of anything new in them is now comparatively rare; and the home geologist cannot but envy his trans-Atlantic cousin when he reads, as he might lately have done, of the return of a company of State geologists from the neighbourhood of the Rocky Mountains, bringing with them two tons weight of fossils!

Those ancient remains, however, have much more to recommend them than merely their quantity. Their discovery has disclosed to us new families and even new orders of extinct animals, and has thus poured a flood of unexpected light on the origin and development of existing life. The

remains are chiefly those of reptiles, birds, and mammals, occurring in rocks of Mesozoic and of Tertiary age, and our knowledge of them is mainly due to the labours of Professors Marsh, Cope, and Leidy. The Rocky Mountains, around which most of these recent discoveries have been made, are believed to have risen out of a great inland sea towards the close of the Chalk period, and that ancient sea would appear to have abounded in what, if seen by ship-captains at the present day, would doubtless have been called "sea-serpents." Palæontologists call them mosasaurs—great swimming lizards, measuring, in some instances at least, sixty feet in length. "On one occasion," says Professor Marsh, "as I rode through a valley washed out of this old ocean-bed, I saw no less than seven different skeletons of those monsters in sight at once."

On the flanks of the same mountains there is a narrow belt of ground traceable for several hundred miles, which contains in great abundance the remains of another group of reptiles known as dinosaurs, and among these occur the largest land animals yet known to have anywhere existed. Some years ago the bones of one of these land monsters were found in Colorado, which must have belonged to an individual measuring about sixty feet in length, and at least thirty feet in height. This *Titanosaurus* has, however, been eclipsed in size by the lately

discovered *Atlantosaurus* of the Rocky Mountains, whose remains prove it to have been about eighty feet in length. Associated with those giants were found the remains of the most diminutive of dinosaurs—the *Nanosaurus*—a creature not larger than a cat.

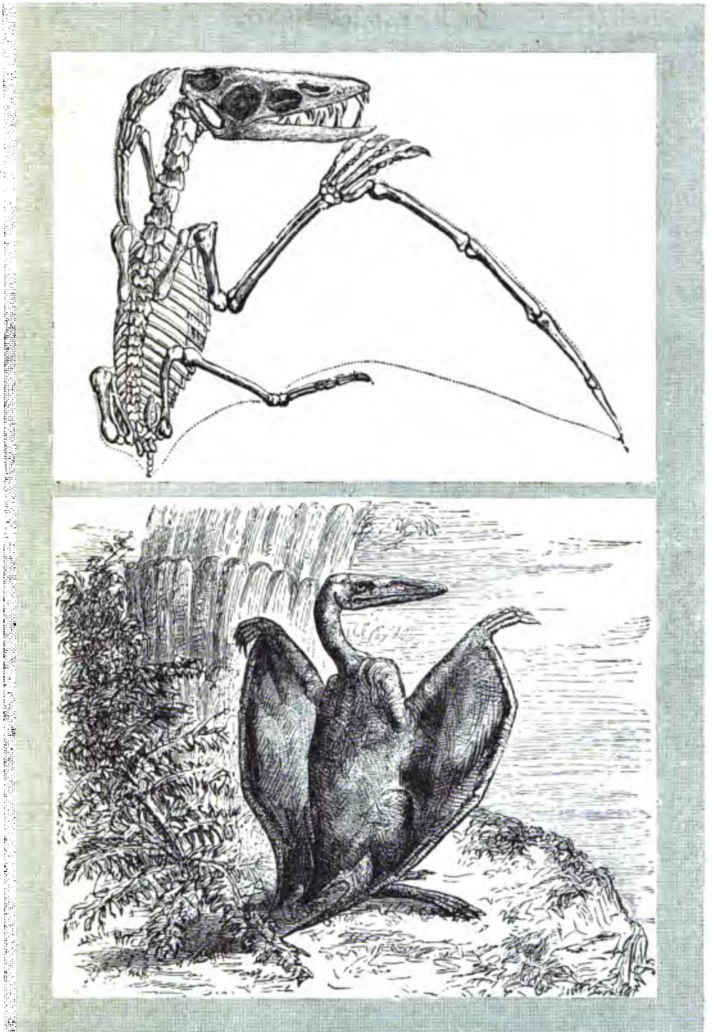
Interesting as those reptiles are from their abundance and bulk, they are still more interesting from their ascertained affinities with birds. Although possessing four limbs, many of them appear to have walked habitually on their hind feet only, probably using their diminutive fore feet to enable them to reach the foliage of the lofty forest trees, which there is reason to believe formed their principal food. In the form of their hind limbs they show a marked resemblance to the giant birds of the ostrich order; and the majority of American palæontologists seem now inclined to believe that the so-called "bird-tracks" of the Connecticut sandstone are in reality the footprints of dinosaurs, more especially as the scanty fossils of those sandstones bear independent testimony to their existence in those times, but not to that of birds.

Judging from the forms now living, no two contiguous classes of animals are more distinctly separate than birds and reptiles, and the opponents of evolution used to point to this fact, and ask how, if evolution were true, the reptile had grown into the bird; what, in short, had become of the host of

links which, according to that theory, must have connected them. Considering the imperfection of the geological record, evolutionists have already done much to silence their opponents on this point. In the Solenhofen slates of Germany a bird has been found possessing a long, jointed, lizard-like tail, reptilian in every respect except that it is covered with feathers instead of scales; while the recent discovery by Professor Marsh of birds with teeth has broken down yet another distinction between them and their reptilian ancestry.

These, forming the earliest-known American birds, were found in the chalk formation of Kansas, and belong to two very distinct groups. The one, *Hesperornis*, was a grebe-like bird, about six feet in length, with small wings, and differing from all known birds in having its jaws armed with teeth, placed, however, not in distinct sockets, but in a common groove; while the other, *Ichthyornis*, had large wings, and had its teeth fixed in separate sockets, while it still further resembled many reptiles, and differed from all recent birds, in having its vertebræ concave at each end.

Another group of extinct reptiles which, if not in the direct line of descent between birds and reptiles, at least show a remarkable mixture of the characters of both, are the so-called "flying dragons," or *Pterodactyls*. These were enabled to fly by means of wings resembling those of the bat



THE PTERODACTYL.
(1. *Skeleton.* 2. *Restored.*)

rather than of the bird. Like the latter, however, their bones contained air-cavities in order to reduce their weight, and their breast-bone was keeled. Until recently they were all believed to possess true reptilian teeth, and such is still the case with all the known Old World forms. Professor Marsh, however, recently discovered a group of giant pterodactyls in the Upper Cretaceous strata of Kansas, which, with their wing expanse of no less than twenty-five feet, must have borne no very remote resemblance to the fabled dragons of antiquity; and those aërial monsters were toothless, their jaws being partly sheathed in horn like the beaks of birds. The discovery thus of bird-like reptiles and of reptile-like birds, has done much to fill up the great gulf which undoubtedly exists between living birds and reptiles.

To the west of the Rocky Mountains the Tertiary formations are represented in a remarkably continuous series of strata, and from these during late years have been obtained by far the most complete set of extinct mammalian remains yet discovered. As might have been expected, the investigation of these has led to the breaking down in many cases of the distinctions on which the classification of living mammals has hitherto been founded, as well as to the establishment of many intermediate groups, such as the tillodonts, which being neither carnivores, ungulates, nor rodents, yet combine in themselves more or less the characters of all three.

Those mammalian remains have likewise furnished naturalists with what may be regarded as the first demonstrative evidence of the truth of the evolution hypothesis. No better verification of a theory can be obtained than when that which, according to it, must be, is afterwards found to be actually the case. According to the general principles of evolution, naturalists had come to the conclusion that the horse, whose feet, as every one knows, consist each of a single toe, with the rudiments of another on either side, must have descended from a quadruped having five equally developed toes on each foot. They long held this view in somewhat the same fashion as did those astronomers who, applying the theory of gravitation, asserted the existence of the planet Neptune some time before the telescope revealed it.

The discovery of a series of fossil horses—numbering over thirty species—in the Tertiary beds of North America, has enabled naturalists to verify their hypothesis by showing, as Professor Huxley puts it, "the coincidence of the observed facts with theoretical requirements." The earliest of the extinct horses yet found does not indeed show five toes on each foot, but it shows four toes on each of the fore feet, with the rudiments of a fifth; and from this point down to the appearance of the existing animal, the series of gradations in the number of the toes, in the character of the teeth,

and in the creature's size, may fairly be regarded as complete. Horses at the present day occasionally revert in the matter of toes to the polydactylism of their ancestors. Thus, Professor Marsh tells of a colt which had three toes on one fore foot and two on the other, and of a mare which had three toes on each fore foot, and a small extra toe on each hind one.

The horse did not exist in America at the time of its discovery by the Spaniards, and this useful animal has therefore been supposed to have been a gift of the Old World to the New. Those discoveries, however, render it almost certain that America is the true home of the horse, which, prior to its extinction there, and while land communication still existed between the two hemispheres, migrated to the Eastern world, from which the invasion of its former highway by the sea prevented return until conveyed back in the ships of the Spaniards.

The camel of the East has lately been introduced into certain parts of the United States, but from the series of extinct camels which have now been obtained from the Tertiary beds of those same districts there is little doubt that the camel, like the horse, has simply returned to its ancestral home. In the lowest of those fossil beds occur also the remains of the earliest known forms of monkeys; and Professor Marsh accordingly claims the ape as

originally an American, although it seems to have left early for the other hemisphere.

An important result which has followed, mainly from the investigation of those fossil remains, is the law of brain-growth. The earliest of those Tertiary mammals had very small brains. Thus in the *Dinoceras mirabile*, a creature nearly as big as an elephant, the brain is proportionately smaller than in any other known mammal—so small, indeed, that the whole of it in its entire breadth could have been drawn through the neural canal of many of the creature's own vertebræ. The onward course of this period is marked by gradual increase in the size of the brain, and by a more convoluted condition of the cerebral hemispheres—showing, as Professor Marsh has said, that in the long struggle for existence during Tertiary times the big brains won then as now.

XXXV.

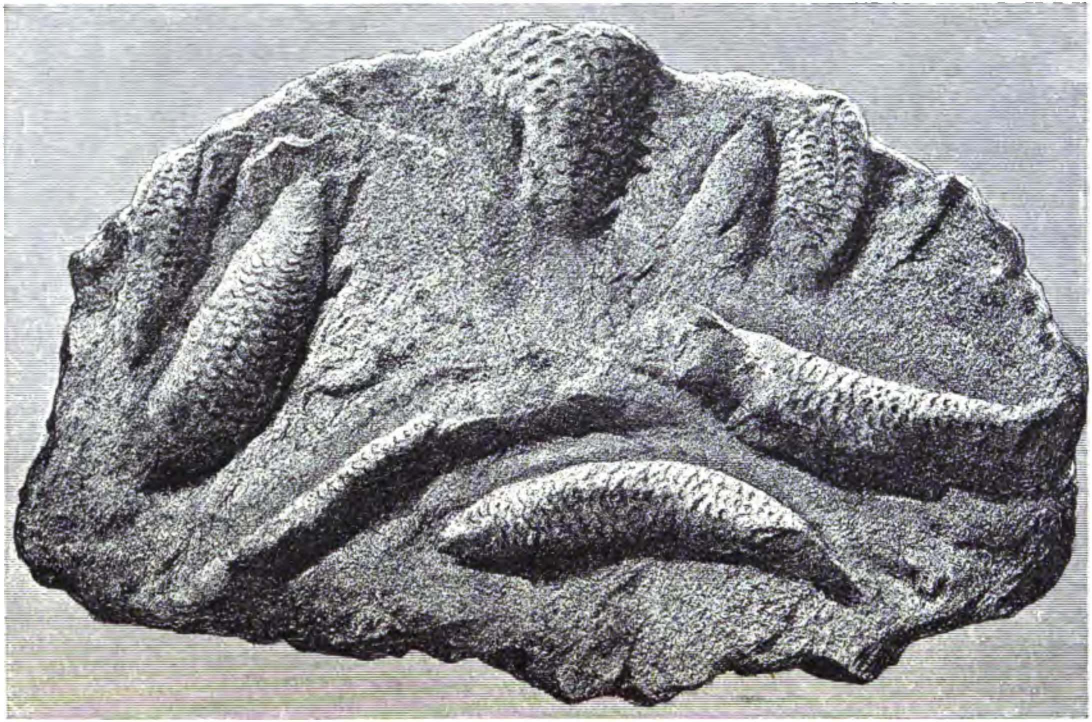
THE FOSSIL FISHES OF SCOTLAND.

FORTY years ago the genius of Hugh Miller did much to popularize the subject of fossil fishes: the dry bones of those ancient animals were made to live again in his unrivalled descriptions, and people who were ignorant of the first principles of geology learned to talk familiarly of the denizens of the Old Red Sandstone. Popular interest, thus suddenly excited, as suddenly collapsed after the death of Hugh Miller, the subject of fossil fishes being once more relegated to purely scientific circles, outside of which it has not been much heard of since. Its progress meanwhile, however, has been none the less real on this account, as the researches of Agassiz, Pander, Egerton, Huxley, and Traquair in this field show.

The labours of Charles Darwin, resulting, as they have done, in a wide acceptance of the doctrine of descent, have given a new interest and impulse to the study of those as well as of all other extinct

organisms. Life has come to be regarded by the majority of biologists as forming one vast genealogical tree, the roots of which are buried deep down in the lowest fossiliferous strata, and the tops of whose branches, constituting the life that now exists on the globe, are alone seen above the surface. According to this now prevalent view, existing organisms are as intimately connected with the past life of the earth as are the twigs with the branches and these with the trunk of a forest tree; so that it is only by a study of the fossil forms that the true relationship subsisting between existing organisms can be elucidated and a natural classification of the animal kingdom established.

Unfortunately for the biologist, it is no part of nature's plan to preserve for his inspection the remains of former life. Nature's law, on the contrary, is "dust to dust," and it is only under exceptional circumstances that this law is evaded and fossils formed. Such exceptions are most frequent in the case of aquatic animals, the fossiliferous rocks having all been deposited under water, just as they are being formed at the present day on the floors of seas and lakes out of the sediment transported by rivers and currents from adjacent lands. The dead or dying fish which reaches the sea-bottom without being devoured, may there, under favourable circumstances, get covered over with an ever-thickening coat of mud, and, thus protected, have its



FOSSIL FISHES OF DURA DEN.

hard parts preserved, to be disinterred, it may be, in future ages when that sea-floor shall have become dry land and its stratified mud shall have hardened into flagstones or shale.

It is not surprising, therefore, that, of all backboned animals, fishes should be the group best represented in the fossil state. Of these the Scottish rocks have yielded a goodly number, the large assemblage of them occurring in the Old Red Sandstone being specially interesting as forming the earliest fish fauna of which tolerably complete remains have yet been found. These are now believed to have inhabited a series of inland lakes or seas which then occupied a great part of the area of Scotland, and in which the rocks of the Old Red Sandstone were deposited. Their remains are chiefly found, not in the red-coloured sandstone, which is singularly barren of life, but in the flagstones of Caithness and Orkney, in which they occur in large numbers, attached to the surface of the fissile stone, like ferns between the leaves of a book. Many of those early fish, such as *Pterichthys* and *Coccosteus*, are totally unlike any of the forms now living, while the vast majority of them belong to the order of fishes known as ganoids, from their scales having an enamel covering not unlike the enamel of the teeth,—a feature to which those ancient fishes owe the fine state of preservation in which they often occur.

For unnumbered ages throughout the Old Red Sandstone, Carboniferous, and Permian eras those beautiful enamel-scaled fishes were the predominant group. They then began to die out; and this process has gone on unceasingly, until at the present day, out of a total of nine thousand species of known living fishes, not more than thirty species of ganoids remain, the inhabitants, for the most part, of rivers and fresh-water lakes. The ganoids have been superseded by the bony fishes, which at the present day are as predominant a group as were the former in Palæozoic times. In the fossil state, modern bony fishes are readily distinguished from the ancient ganoids by the absence of scales, these appendages in the former, owing to the absence of enamel, entirely disappearing during the fossilizing process.

Most of the Old Red Sandstone fishes were comparatively small, although a few seem to have attained gigantic proportions, the remains of one of these—a species of *Asterolepis*, found both in Russia and in Scotland — indicating a creature nearly thirty feet in length. From the immense number of fossil fishes sometimes found congregated together in one place, it has been supposed that in such cases they must have met with sudden death, and with as sudden burial. Thus Anderson, in his work on "Dura Den," states that a space of little more than three square yards in that highly fossilif-

erous portion of the Old Red Sandstone yielded no fewer than a thousand fishes, most of them in perfect outline. Lyell, speculating on the cause of this mortality, is inclined to attribute it to the discharge of noxious vapours during earthquakes and other similar convulsions, by which fish-life was suddenly rendered impossible over certain areas; and several cases are on record of immense numbers of fishes being thus destroyed in modern times.

The Carboniferous period, which succeeded the Old Red Sandstone, is largely represented in the southern half of Scotland, and is likewise rich in remains of extinct fish, the majority of these belonging, as in the preceding period, to the order of ganoids. Of those, one of the most noteworthy is the great *Rhizodus hibberti*, which must have measured over twenty feet in length, and whose predatory habits are indicated by its great strong teeth, many of these measuring over four inches in length, while its nearly circular scales, judging from an example in the possession of the writer, must have occasionally measured three inches across. This formidable fish was a denizen of Midlothian when that county, along with the rest of the basin of the Forth, formed, according to Dr. A. Geikie, a region of shallow lagoons, islets, and coal-growths, dotted over with innumerable active volcanic vents. Its remains got buried in those lagoons, and they are now not unfrequently met with in the iron-

stone of Gilmerton and Loanhead, as well as in the limestone of Burdiehouse.

The latter has, during the past half-century, formed a perfect storehouse of fossil fishes, although of late years it has become much less productive. The same may also be said of the Wardie shales, which yielded some of the earliest fossil ichthyic remains found in Scotland, many of which were afterwards described by Agassiz. Here the fossils are obtained, not in the shale itself, which forms a feature on the shore between Newhaven and Granton, but in the ironstone nodules—curious oval concretions which may be seen imbedded here and there in the shale like almonds in a cake. These are usually less than a foot in length, but recently (1880) a nodule nine feet long was dug out of the shale, and on being split was found to contain an entire specimen of *Rhizodus*—the first complete specimen of this huge fish ever obtained.

These nodules are the result of the aggregation around some vegetable or animal organism of the mud and iron suspended or dissolved in the water, just as nodules are being formed at the present day in peat-bogs, which, according to Sir Joseph Hooker, are altogether analogous to those of the Carboniferous period, both in form and in chemical composition. Hundreds of such nodular stones, round or oval, may be found scattered along the Newhaven shore, these almost invariably being found, when

broken across, to contain coprolites of one or other of the many ganoid fishes and sharks which in Carboniferous times frequented those waters. Sometimes, although rarely, they contain a piece of fern or other plant; but those are more usually found in the shale itself.

Those Wardie shales can be traced, chiefly in the bed of the Water of Leith, for many miles to the south; but they become much less nodular after leaving the shore, and fish remains in them grow correspondingly rare. On the other hand, the shells of mollusks, which are excessively scarce at Wardie, occur in many parts of the inland shale in great abundance. Thus, near the railway station at Juniper Green, the Water of Leith flows over an exposed surface of shale which is almost entirely composed of bivalve shells. These, when seen under an inch or two of water, show a white, shelly aspect, which gives them an altogether recent appearance, although in reality they are among the oldest fossil remains in the neighbourhood of Edinburgh.

Another great repository of the fish-life of this early period is the shale and accompanying strata now so largely worked for the sake of the mineral oil it contains. Overlying the oil-shale, there occurs a non-bituminous stratum, known to the miner as "blaes," useless for the purpose of the paraffine manufacturer, but often rich in organic remains, especially in plants. Like the shale at Wardie, this

"blaes" frequently contains large oval concretions, which, when split longitudinally, are often found to contain beautifully preserved ferns, the plant showing a brilliant metallic lustre, as if it had been copied in brass. Occasionally, though rarely, those "cement-stones," as they are sometimes called, contain the heads and more or less of the bodies of ganoid fishes,—rarely, however, in a good state of preservation. The same shale affords abundant evidence of the presence of sharks; these, however, being cartilaginous fish, nothing more is found of them than patches of the shagreen with which, as in modern sharks, their bodies were covered, and the spines, with which they no doubt attacked their enemies and defended themselves. Direct evidence of the predatory habits of many of those ancient fishes has been obtained in the presence of more or less perfect specimens of small fish in the stomachs of their larger congeners.

XXXVI.

FOSSIL BIRDS.

THE undeniable fact that animals as they now exist are divisible into well-marked groups gave probability to the view that they had been created so. When the evolutionist, on the other hand, maintained that they had been derived from a common stock, the intervals which now separate them not being parts of an original design, like the walks in a well-planned garden, but merely gaps caused by extinction in the otherwise unbroken sequence of life, the special creationist demanded the production from that great storehouse of extinct life—the fossiliferous rocks—of some at least of those intermediate forms which must have existed if what is now so markedly asunder had at one time been joined together. In excuse for the non-production of such evidence, the evolutionist could only point to the undoubted imperfection of the geological record, and to the still greater imperfection of our acquaintance with what remained of it. Much, however, has been done, since

the publication of Darwin's "Origin of Species" gave direction to palæontological research, to remedy the latter evil; and if less is now heard than formerly of the demand for the production of intermediate forms by the opponents of evolution, it is simply because its advocates, instead of pleading excuses for the absence of such forms, have lately taken to proving their presence.

Their success in this direction may be fairly illustrated by a reference to the case of birds, which form one of the best-marked groups in the whole animal kingdom. It would be difficult to find a greater contrast among animals than that afforded by those feathered bipeds and the different groups of reptiles, whether snake, lizard, tortoise, or crocodile; yet reptiles stand next to birds in the scale of organization, and the doctrine of descent points to the avian as having been evolved from the reptilian type.

How far, it may be asked, is this theory borne out by the evidence in past times of the existence of birds more reptile-like, and of reptiles more bird-like, than any now living?

The fossil remains of birds are comparatively rare, not necessarily because birds were scarce in past ages, but probably because their habits rendered them less liable to get into the position necessary for their preservation. "The powers of flight," says Sir Charles Lyell, "possessed by most birds would

insure them against perishing by numerous casualties to which quadrupeds are exposed during floods," while "if they chance to be drowned or to die when swimming on water, it will scarcely ever happen that they will be submerged so as to become preserved in sedimentary deposits." Their carcasses, owing to the lightness of their bones, would keep long afloat, and would thus frequently become the food of predaceous animals. Although, therefore, nowhere abundant, the fossil remains of birds have been found scattered throughout the Tertiary and Post-Tertiary deposits.

The bogs of New Zealand have yielded the half-fossilized remains of the gigantic but now extinct moas—huge wingless birds, some of them ten feet in height; while the surface deposits of Madagascar have yielded the remains of the still more massive *Æpiornis*, whose eggs have been found measuring over thirteen inches in diameter, and having a capacity equal to one hundred and forty-eight hens' eggs. From the Miocene beds of France some seventy species of birds have been obtained, chiefly interesting, however, as belonging in the main to groups not now represented so far north. These included parrots and trogons, flamingoes, secretary birds, and marabout storks, and thus bore a considerable resemblance to the present bird fauna of South Africa.

The still older London clay of the island of

Sheppey yielded to Professor Owen the remains of a vulture, a kingfisher, and an ostrich; also, what was more interesting still, the remains of a web-footed bird, *Odontopteryx*, which at first sight appeared to be provided with teeth. Closer examination, however, revealed the fact that these were merely tooth-like serrations on the edges of the jaws, similar to those found on the bill of the goosander at the present day, only much more pronounced. Professor Owen supposes the bird to have been a fish-eater, and that in the catching of its slippery prey it was assisted by this pterosauroid armature of the jaws. Thus far the Tertiary formations have only revealed *true* birds, and the existing gap between feathered bipeds and reptiles, so far as palæontological evidence goes, would seem to have been as decided then as now.

Going still further back in geological time, the Mesozoic era is reached, and in the final stage of that era—the Cretaceous period—the evolutionist has at length obtained evidence of the existence of forms in some respects intermediate between bird and reptile. Professor Marsh has found, in those Cretaceous rocks of America which have yielded such an abundant harvest of vertebrate remains, the skeleton of a bird which, had it wanted the head, would probably, says Professor Huxley, "have been placed in the same group of birds as the divers and grebes of the present day." The head, however, was for-

tunately not awanting, and it showed that the *Hesperornis*, as it is called, differed from all existing birds, and so far agreed with reptiles in the possession of true teeth. These teeth are placed in a groove along the edges of both jaws; but in another bird—*Ichthyornis*—which has been discovered in the same beds, and which also possesses teeth, each of these is lodged in a distinct socket. The latter bird still further differs from all existing birds, and approaches reptiles in having its vertebræ concave at each end.

In spite of their teeth, those Cretaceous forms are undoubtedly much more nearly related to birds than to reptiles. In the rocky record, however, of the immediately preceding period—namely, the Jurassic—the fossil remains of a creature have been found, which, in spite of certain highly ornithic characters, is now regarded as approaching more nearly the reptilian type. This is the *Archæopteryx*, found in the lithographic slates of Solenhofen, and the structure of which has only recently been fully described by Professor Carl Vogt. All that was known of this form for a considerable time was a single feather, or rather the impression of it, found on a slab of lithographic slate. This bird of *a* feather, as Lord Dundreary would have called it, was obtained soon after on a slab of the same limestone, in much greater detail; it wanted, however, the head, and was in several other respects defective.

The third and only other specimen yet found is said to be nearly perfect, and is the one described by Professor Vogt, whose description supplements, and to some extent corrects, that given by Owen of the specimen now in the British Museum. The archæopteryx had the legs and feet of a bird, and from the structure of these it was probably a percher; its wings, however, were unlike anything found among existing birds. The wing of a bird corresponds to the fore leg of a quadruped and to the arm of a man; but in a bird the bones which correspond to those of our hand, instead of being free as they are in the human fingers, are bound up, with the exception of the last joint of the thumb, in a sheath of skin, and form a foundation for certain of the wing feathers. In the wing of the archæopteryx, as now known, there were three digits, each of them free, and bearing true reptilian claws at their extremity. They thus show no special adaptation to the support of wings; and had the feathers, therefore, not been preserved, no one could have suspected from a study of the skeleton that the creature had been furnished with such organs of flight. The feathers, however, are unmistakably ornithic, covered for half their length with fine down, and none of them projecting beyond the others. In the new specimen the feathers are all in place, and the wings are unfolded as if in flight; but from the rounded appearance they present, reminding one of the wings

of a fowl, it is probable that the archæopteryx had comparatively weak flying powers. It is also supposed by Vogt, from certain faint indications, to have had a downy collar at the base of its neck like that of the existing condor, and it undoubtedly had "feathery breeches" like those of the falcon. No trace, however, of body feathers appears on this slab, which has preserved even the smallest details of the fine down. It may be concluded, therefore, that with the exception of the parts already mentioned, the archæopteryx was not, as it is usually represented in drawings to have been, feather-clad.

This earliest of feathered creatures is now known also to have had true teeth. Its most strikingly reptilian feature, however, is its tail. In existing birds the tail is short, consisting of only a few vertebræ, two or three of which coalesce to form the last or "ploughshare" bone, which gives attachment to the quill feathers of the tail. In the archæopteryx there are twenty narrow elongated vertebræ, which gradually taper, as they do in reptiles, towards the extremity, while to each vertebra is attached a pair of feathers. According to Professor Vogt, "it is quite unnecessary to discuss the question whether the archæopteryx is to be classed among birds or reptiles. It is neither one nor the other; it constitutes an intermediate type of the most strongly-marked character......The archæopteryx is undoubtedly one of the most important sign-posts on the

road which has been followed by the class of birds in differentiating itself more and more from the reptiles from which it originated. A bird by its integument and hinder limbs, the archæopteryx is a reptile by all the rest of its organization; its conformation can only be understood by accepting the evolution of the birds by a progressive development from certain types of reptiles."

XXXVII.

THE EXTINCTION OF THE GREAT AUK.

At a comparatively recent period in geological time none of the animal forms now living, with the exception probably of a few of the lowest organisms, had come into existence. Air, earth, and water were inhabited then as now, but by an assemblage of creatures only known at the present day through their fossil remains. The disappearance of this ancient fauna seems to have been neither sudden nor simultaneous. In the never-ending struggle for existence, its members fell one by one before the superior organization and vigour of later forms; but the old fell and the new rose at such wide and irregular intervals that the difference at any one time in the *personnel* of the ranks of life must have been as imperceptible as the motion of the hour-hand on a watch-dial. Life is still in the grip of the self-same forces, and may therefore be presumed to be undergoing similar changes; certain it is, at least, that now, as formerly, species are dropping

at intervals from the ranks, and disappearing for ever.

Attention was lately directed to what is probably one of the latest instances of extinction by the discovery in Edinburgh of two eggs of the great auk or garefowl. Other birds are known to have become extinct during the human period, as the gigantic moa of New Zealand, the dodo of Mauritius, and the solitaire of Rodriguez; but in this country special interest attaches to the great auk, as having been a British bird, or at least a frequent visitor to our shores. It was one of the largest of sea-fowl, measuring about three feet in length, and on land assumed a nearly erect, penguin-like position. Its weak point was its wings, which were short fin-like organs, of service to it as paddles in the water, but wholly useless as organs of flight. Thus comparatively helpless on land, it must have fallen an easy prey to the islanders whose shores it frequented, and to whom its heavy carcass offered a tempting supply of animal food. Its reproductive powers would seem also, if early writers are to be trusted, to have been unusually limited, as it is said to have laid only one egg in the season.

Those birds seem to have been sufficiently common during prehistoric times on the shores of Denmark, and even of Scotland, to have formed an article of human food, their bones having been found in the kitchen-middens of both countries. Driven from

those shores by our savage ancestors, they appear to have sought refuge on the rocky and more or less inaccessible islets of north temperate seas, where alone they have been found during the historic period. Nearly two hundred years ago, "M. Martin, gent.," visited in an open boat the island of St. Kilda, and in his published account of the voyage he describes with considerable accuracy the appearance of the garefowl, which, he says, was "the stateliest as well as the largest of all the fowls here." He also states that it was only a summer visitor, reaching St. Kilda early in May, and leaving again in the middle of June.

How long it continued to pay regular visits to "the remotest of all the Hebrides" is not known, but a specimen—interesting as being the last seen alive in Scottish waters—was captured off St. Kilda in the year 1821. The late Dr. Fleming of Edinburgh, when on a cruise among the Hebrides, had this specimen put on board the yacht by its captor. It looked emaciated and sickly, but under a generous regimen of fish and an occasional bath, which it was permitted to take in the open sea with a cord fixed to its leg to secure its return, it soon regained its native sprightliness. The consideration thus shown for its comfort led, however, to the loss of the specimen. In the words of a friend of Dr. Fleming's, "its love of liberty eventually proved stronger than the cord by which that liberty was

restrained, for during a subsequent washing with which it was considerately favoured off the island of Pladda, to the south of Arran, it burst its bonds, and was seen no more for ever."

The great auk appears also to have been at least an occasional visitor to the Orkney and Shetland islands so late as the beginning of the present century, Mr. Bullock, a keen ornithologist and collector, having, while on a visit to those islands in 1812, pursued a male, called *King of the Auks* by the natives, for several hours in a six-oared boat without being able, such was its dexterity in diving and swimming under water, to capture it. It was afterwards killed by the boatmen, who forwarded it to Mr. Bullock, on whose death it was purchased for £15, 5s. 6d., and deposited in the British Museum. In 1834, another garefowl was caught alive in Waterford harbour, and its stuffed skin now forms one of the treasures of Trinity College Museum, Dublin. Since that time there is no well-authenticated instance of its occurrence in British waters. It has occurred, however, in other quarters.

Off the coast of Iceland there are three island reefs or skerries which take their name from the garefowl, and there is abundant evidence that on one of these at least the bird lived and bred in considerable numbers during the last and well into the present century. The crew of a Faëroese vessel

made a descent on this skerry in 1813 and killed a large number of garefowl; while in 1830 the remnant of this ancient race was still further reduced by the sinking of the skerry beneath the waves during a submarine eruption. The survivors, or part of them, migrated to an island nearer the mainland, where, owing to its greater accessibility, the birds fared worse than ever. "In the course of the next fourteen years," says Professor Newton, who is *par excellence* the historian of this bird, "their numbers annually dwindling, probably not less than sixty of these birds were killed in the newly-selected locality." The last of these—a pair—were taken alive in 1844, and conveyed to the Royal Museum of Copenhagen, where their bodies may now be seen preserved in spirits.

The most important locality for the great auk during historic times seems, however, to have been certain small islands off the coast of Newfoundland, where the death-knell of the species may be said to have been struck by the discovery of America. Lying in the way of mariners going to and from the New World, the sight of those birds in enormous abundance led to those islets becoming a sort of victualling station, where the carcasses of garefowl formed an apparently exhaustless source of savoury animal food. The wholesale destruction of the birds and their eggs which ensued ended, as it could only end, in their total extirpation, which is believed to

have taken place much earlier in that locality than in Europe. Forty years ago those islands were visited by a Norwegian naturalist, in order to see what proof might still exist of those early ornithic massacres, and he found still standing the rude stone "pounds" into which the hapless birds had been driven by the sailors, as well as large quantities of their bones. Very recently, also, an Englishman—Mr. J. Milne—landed on the same island for a similar purpose, and brought off the remains of fifty great auks, some of them, according to Professor Newton, exceeding in size any that had before been seen.

Species supposed to be extinct have, however, been known to turn up alive: thus the New Zealand *Notornis* was long known only by a few of its bones, until a live specimen was caught by some sailors and eaten! A second specimen has since been taken. That the great auk may thus also be stumbled upon is in the highest degree improbable. For nearly forty years the search for it has been in vain; and although the polar regions have by no means been completely explored, all the evidence is, with one doubtful exception, opposed to the view that the garefowl ever was an arctic species.

If our forefathers have thus ruthlessly killed the bird, we are making what amends we can by preserving with scrupulous care its dead remains. Every skin, skeleton, and egg of the great auk

which is known to exist has been duly chronicled, and its history, as far as possible, traced; while the appearance of any of those coveted objects in the market generally gives rise to a brisk competition between the two hemispheres for its possession. Skins which brought £15 at Mr. Bullock's sale in 1819 are now worth ten times that amount; while eggs—which are scarcer than skins—bring many times their weight in gold. Four, which were sold in 1865, realized on an average £30 each; while so rapidly did their value increase that another, sold a few years later, brought £63. In 1871 there were known to exist, according to Professor Newton, in public and private collections, nine skeletons, seventy-one skins, and sixty-five eggs of this bird, two of the eggs being in the Edinburgh Museum. The total number of eggs has now been increased by the pair above referred to, which formed part of a miscellaneous collection of natural history specimens sold by auction in Edinburgh. As neither the owner in whose possession they had been for thirty years, nor any of those who saw them "on view," with the exception of their purchaser, seem to have known what they really were, they realized an insignificant price. Those eggs have since been resold in London, when they realized the enormous and altogether unprecedented price of a hundred and a hundred and two guineas respectively! "Penguin" is the name by which the great auk

was known in Newfoundland, and the fact that those eggs were thus marked suggests for them a trans-Atlantic origin. That these rare eggs should have been in an Edinburgh collection for so many years without being known, renders it probable that the tale of existing specimens may not even yet be all told.*

* Since the above was written, the author was fortunate enough to learn that a stuffed specimen of the great auk existed, unknown to ornithologists, in the collection of his Grace the Duke of Roxburghe at Floors Castle. At his request the duke allowed this *rara avis* to be exhibited at a meeting of the Royal Physical Society, Edinburgh (April 1883), and the illustration at the beginning of the present volume is from a photograph of the bird which the duke kindly granted permission to be taken.

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